Cement MILL EDITION of

Concrete

Devoted to the Manufacture,
and Use, of Portland Cement

AUGUST, 1934

400 West Madison Street
Chicago, Illinois

UNITE TO FIGHT DIVERSION

◆

FORTY-THREE regular state legislative sessions will convene early in 1935. In each one of them insistent demands will be made for increased revenues.

℄ Instinctively, the eyes of legislators will turn toward the continuous flow of the ready cash contributed by motorists—ostensibly for the construction and maintenance of roads, but now being diverted to other uses in an amount exceeding 100 million dollars annually.

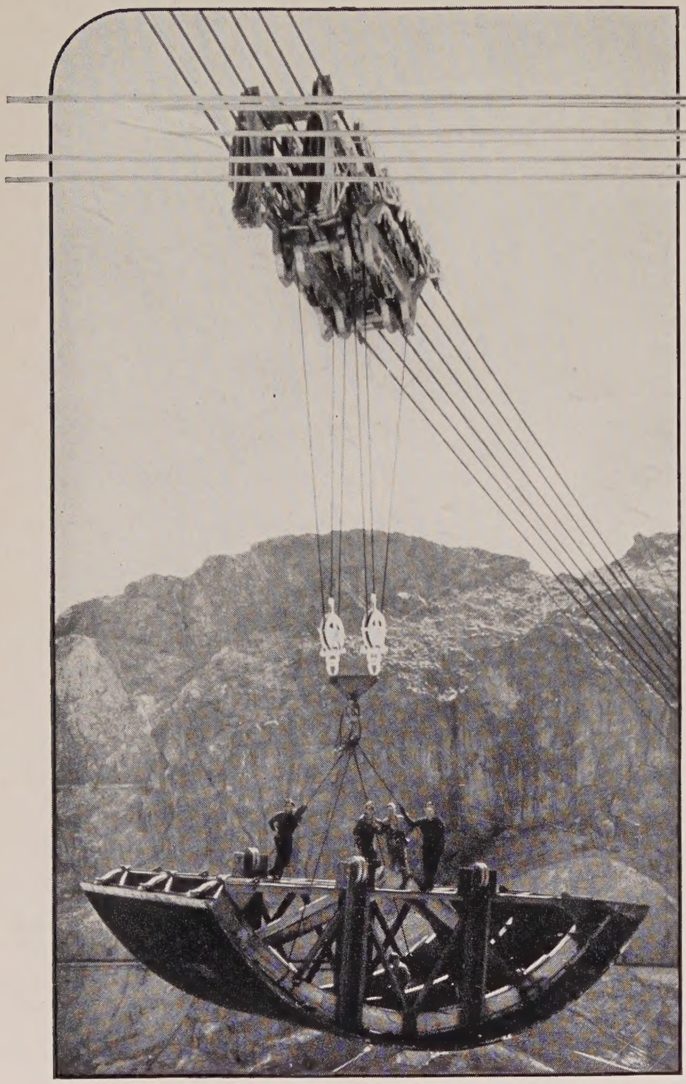
℄ There will be further diversion of these highway funds unless all friends of more and better highways present a united and well-organized front of opposition.

℄ In this opposition the National Highway Users Conference is taking a leading part. Through affiliated organizations in various states, candidates for public office are asked to indicate what positions they will take in the matter of diversion of gasoline tax and automobile license funds — and whether they will work toward a reduction of the present diversion.

℄ Every possible measure of support for this movement should be extended to the National Highway Users Conference by organizations representing the concrete construction industry.

℄ And after this check-up on candidates is completed, there will be other work to do—work that can be accomplished only by united and organized effort.

THE AIR ROADS ARE ALWAYS OPEN



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Vol. XLII, No. 8 Concrete August, 1934

Make Heavy Precast Concrete Units in Well-Organized Field Plant

How High-Early-Strength Cement Speeds Production—Concrete Delivered by Truck Mixers and Discharged Into Lines of Metal Molds—High-Frequency Vibrators Employed

A FIELD plant for precasting large reinforced concrete units utilized as diffuser plate containers and separators in the construction of Milwaukee's new sewage disposal project constitutes an interesting example of field organization and layout for work of this type.

The precast units required for this project are beam-like products about 12 ft. long, of two different cross-sections, one type of unit weighing about 850 lb. and the other about 1,150 lb. each.

Inasmuch as some 6,500 of these units were required on the Milwaukee sewage disposal project,* the Sewerage Commissioner let this special work to Roland H. Becker, Contracting Engineer, Elm Grove, Wisconsin. Under the direct superintendence of Mr. Becker, the casting yard for the production of the precast units was laid out and organized so that the work could be accomplished in a regular cycle.

Selecting the Materials

The selection of suitable materials and equipment naturally constituted an important element in the success of the operation. For illustration, it appeared from the schedule of delivery that it would be necessary to cast 63 units each working day (5 days per week). Next came the selection of the molds; and for this purpose metal molds were decided upon.

It was further decided that by using high-early-strength cement in the concrete mixture, the metal molds could be stripped and reassembled in time to be re-used each day. This meant that 63 molds would be required, since, as previously explained, 63 units were to be cast each day.

Aggregates for this work include a crushed limestone ranging in size from ¾ in. down to the No. 8 sieve, together with washed sand ranging from the size passing the ¼-in. sieve down to the size retained on the No. 100 sieve. Sixty per cent of the sand is retained on the No. 50 sieve. This small-size coarse aggregate has an average fineness modulus of 6.31, while the sand averages around 2.93.

The quantity of water in the mixture is 6 gallons to the sack of cement, and proportions between aggregates, and between aggregates and cement-and-water, are maintained in accordance with the characteristics indicated by the fineness moduli, and so as to produce a slump of 2 in.

Delivery and Mixing of Concrete

A rather unusual procedure is being followed in the delivery and mixing of the concrete. Properly proportioned batches are delivered to the casting yard in 3-yd. Rex moto-mixers, after which the water is added and the mixing drum is rotated for 15 minutes. The purpose of this procedure, of course, is that of giving the superintendent absolute control of the mixing time. The resultant concrete is thoroughly mixed to a uniform consistency, and it has a high degree of density as well as high strength.

The concrete is discharged directly from the mixing trucks to the metal molds, through short swinging chutes, and is worked into place by a portable high-frequency vibrator placed near the mid-point of the mold. The working crew consists of seven men, two of whom are engaged in placing the concrete, and two operate the vibrator. Test cylinders are taken once a week.

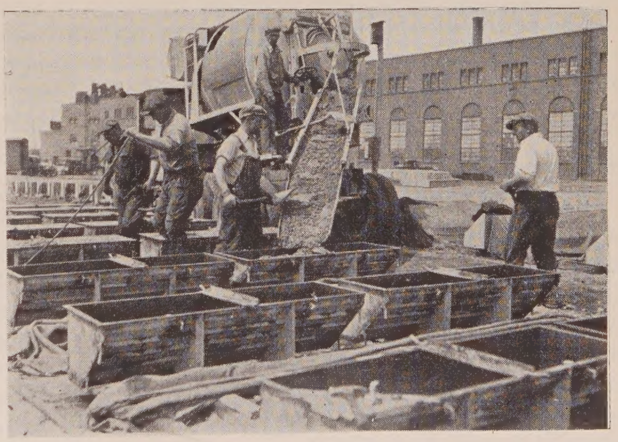

Figure 1. Concrete is discharged direct from truck mixers to metal molds. Two men farthest from camera are operating high-frequency vibrator

Curing the Concrete

The metal molds are removed not later than 18 hours after the concrete is placed. In the meantime the top

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*The Milwaukee sewage disposal project is an 8-acre extension to that city's present disposal plant. The new work is described in an illustrated article on pages 3 to 5 of the June (1934) issue of Concrete.

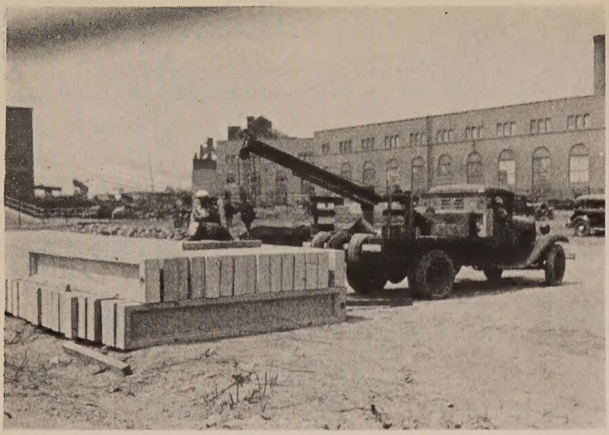


Figure 2. Precast units are moved by portable crane

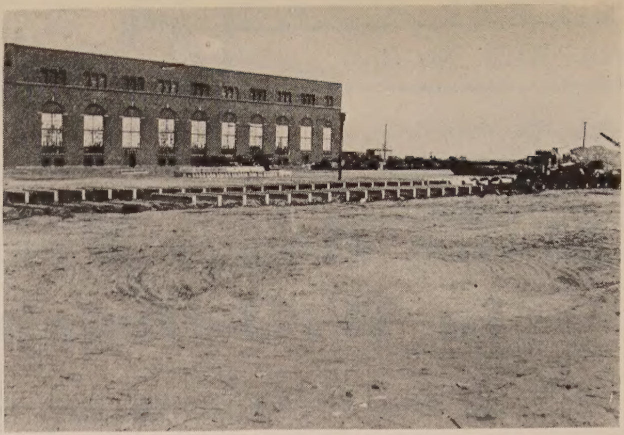


Figure 3. Precast units in storage at casting yard

(exposed) surface of the units has been covered with four thicknesses of Canton flannel and one thickness of 10-oz. burlap and kept moist. During this first period the wetting is continuous. After removal of the molds the units are kept damp for an additional period of two days, the covering being left in place.

The Working Routine

Stripping of molds from the previous day's casting is started at 6:00 A. M. By 8:00 A. M. all the molds have been stripped and set up in a row for the next casting. One mold can be stripped and set up again in 6 to 7 minutes.

The arrangement of the molds, as may be seen in Figure 1, permits the mixing truck, with its charge of 3 cu. yd. of concrete, to pass along the line of molds and discharge the required amount of concrete into each. In this illustration (Figure 1) the two men farthest removed from the camera are operating the high-frequency electrically-driven vibrator.

The newly-filled molds are, of course, undisturbed except for the covering and wetting, until the morning of the following day, when they are again removed and set up for that day's run.

High-Early-Strength Cement Speeds Work

Due to the use of high-early-strength cement it is possible to handle the precast units immediately after the molds are stripped (about 18 hours after placing the concrete). Figure 2 shows the method of handling, by means of a portable crane. As the illustration shows, the units are now piled closely, but with sufficient space between units to permit them to be kept moist on all sides. These piles are then covered with burlap and kept moist for an additional period of two days, as previously described. After the 2-day curing period the units are transferred to storage, along one side of the casting yard, shown in Figure 3.

The casting yard is located within a few blocks of the site where the 8-acre extension to the sewage disposal plant is being built. The schedule has been arranged to cover a period of about 5 months, the crew working 5 days a week, 6 hours a day. In a word, the construction day extends from 6:00 A. M. to noon.

The 63 metal molds employed in this work were manufactured by the Metal Forms Corp., of Milwaukee. The high-frequency vibrator used in placing the concrete is the Syntron vibrator. "Incor" high-early-strength cement is used. The use of this cement, as already explained, permits early removal of metal molds, as well as early handling of the precast units. The small additional cost of the high-early-strength cement is more than offset by these advantages.

Darwin W. Townsend is acting chief engineer of the Milwaukee Sewerage Commission, under whose direction this sewage disposal plant is being constructed as a PWA project. Walter W. Genrich is assistant to the chief engineer. As previously indicated, the contractor is Roland H. Becker, contracting engineer, Elm Grove, Wis.

Curing Concrete Pavement with Calcium Chloride

Ohio Highway Department Experience Shows Favorable Influence of Chemical

A REPORT by R. R. Litehiser, chief engineer of the bureau of tests, Ohio State Highway Department, issued under date of March 15, 1934, and abstracted in *Highway Research Abstracts*, June, 1934, presents data comparing the compressive strength of cores cut from calcium chloride-cured pavements or bases with cores cut from other concrete pavements or bases cured with water. The comparisons are made for concretes having the same proportions and coarse aggregates and cover pavements built during 1933.

GENERAL SUMMARY OF STUDY OF CALCIUM CHLORIDE CURING (BY MEANS OF CORE COMPRESSIVE STRENGTHS)

1933 Cores—October-November, 1933

Mix	Age in days	*Water curing, avg. compressive strength, lb. per sq. in.	Calcium chloride curing	
			Avg. compressive strength of cores, lb. per sq. in.	Percentage of average water-cured concrete
1-5½ Gravel	7	3,152	3,697	117
1-5½ Gravel	12	3,716	4,258	115
1-5½ Gravel	14	3,951	4,510	114
1-5½ Gravel	28	4,704	4,487	95
1-5½ Limestone	28	3,900	4,000	103
1-6 Limestone	7	2,869	2,692	94
1-6 Limestone	14	3,597	3,928**	109
1-6 Limestone	28	4,282	3,723	87
1-7½ Gravel	7	2,710	2,545	94
1-7½ Limestone	7	2,874	2,535	88
			Average	102

*Computed average of all water-cured cores tested in 1933 with the same mix and coarse aggregate.

**These cores held 2-3 days in laboratory before testing.

Control of Ready-Mixed Concrete by Trial Mixtures

Method Advocated as Most Practical in Sections Having Definite Sources of Aggregates—Properties of Available Materials Must Be Studied Thoroughly

By K. M. McKELVEY
Concrete Technician, Butler, Penna.

Not all concrete technicians will agree with this writer's assertions regarding the practical value of trial mixtures—supplemented, of course, with determinations of fineness modulus. Nevertheless, the author makes out a good case for his claims, especially in sections where the sources of supply of concrete aggregates are definitely known.

In the concluding installment he will set forth in detail his methods of procedure.—Editor.

THE ready-mixed concrete industry in the last six or eight years has become a factor of importance in supplying the concrete needs of the community. The industry has suffered along with the building supply industry in general the effects of retarded construction, but it is still producing respectable daily yardages.

In 1929 and 1930 the average plant maintained a daily minimum production of 100 cu. yd., while 500 cu. yd. or better for one unit was not an infrequent occurrence. At the present time the maximum daily production is probably 100 cu. yd., with the average well below this figure.

Central or Truck-Mixed Concrete?

The type of plant to develop in a given locality (central or truck-mixed) depends on local preferences and costs, of course; but other factors are of importance, such as length of haul, characteristics of aggregates, type of demand (pavement or structural), and various related factors.

Ready-mixed concrete has a certain advantage not apparent in job-mixed concrete. It is capable of supplying large yardages in a limited time, thus reducing job-overhead costs materially. It is inherently subject to economies of operation unattainable at the usual building site. It is very flexible in placing, thus tending to reduce its cost.

Importance of Control

The modern plants in use, as well as the technical control and testing possible with large yardages, give ready-mixed concrete an advantage in uniformity of strength and quality. It is a specialization in manufacturing which tends to reduce structural costs and increase the potentialities inherent in concrete of uniformity and quality.

Ready-mixed concrete has been fortunate, inasmuch as it has been welcomed from its inception by architects and engineers as a uniform and dependable product. In order to maintain and merit this esteem, the concrete manufacturer must be ahead of his field in the quality of his output. No element is of greater importance in this respect, and in building up sales, than the field control of quality.

NOTES ON DESIGN

Three major considerations enter into the question of the design of ready-mixed concrete. These are *Yield, Workability* and *Strength.*

The problem may be defined by stating that the design of ready-mixed concrete consists of the formulation of simple rules of proportioning and set-ups for the materials found in a given district to give the best yield of workable concrete having a high strength and density.

These considerations enter, of course, in greater or less degree into the design of a mix for any particular structural purpose. However, the emphasis is changed from the design for a given structure to that of a design for a series of mixes suitable for many purposes, in which a variety of aggregates ranging from gravel, stone and slag to special light-weight aggregates such as haydite and cinders may be employed.

Methods of Proportioning

Uniformity of yield, workability and strength are prime essentials, and are considered under control measures.

All methods of design are justified in so far as they produce a quality concrete. The methods of proportioning generally in use may be stated as follows—

1. Arbitrary mixes based on the unit weights.
2. Use of fineness modulus formulas.
3. Use of trial mixes.
4. Combination of trial mixes and fineness modulus.

(1) *Arbitrary Mixes.* The use of arbitrary mixes are not justified on grounds of workability and uniformity of strength and yield. There may be some districts having such a uniformity of grading and unit weights of materials as to produce good concrete with this system; but in general these mixes produce undersanded harsh concrete lacking in workability and uniformity.

These arbitrary mixes are the result of an inelastic and uninformed use of past experience, and are not in conformity with modern research in concrete. In practice, on the individual job, these mixes are modified under the watchful eyes of a good inspector, to produce a more workable mix. This modification should take place early in the life of a ready-mixed operation along simple proportioning lines.

(2) *Fineness Modulus.* The fineness modulus theory of proportioning is of limited utility when used by itself. It has value, however, in conjunction with trial mixes, in finding the percentage of sand above and below which the mix may be varied, and in combining two or more sizes of coarse aggregate. The fineness modulus formula is also of value in its simple statement of rules of proportioning on encountering changes in materials.

In general, care must be exercised in choosing values for the fineness modulus of mixed aggregate so that the values selected conform with peculiarities of local aggregates. The formula will generally give a higher percentage of sand in the mix than can be justified by the workability and density desired.

Where the sand is notably deficient in a given size, more attention should be paid to the sieve analysis than to the fineness modulus.

(3) *Use of Trial Mixes.* I consider the extensive use of trial mixes resulting in a sound knowledge of mix set-ups and of the properties of the aggregates and resultant concrete as the best system of proportioning for ready-mixed concrete.

Trial mixes should be made covering the range of principal mixes and slumps in demand in the district, varying the sand content until the best percentage for yield and workability are arrived at for average materials. Properties of the materials used in these mixes, such as grading, specific gravity and weight per cubic foot, should be recorded for future reference. The effect of variations in these properties may be studied with the view of developing rules of proportioning and control measures necessary to counteract these variations.

These trial mixes should be repeated at intervals, until a thorough knowledge is attained of the following factors:

A. Yield with the aggregates available.
B. Range of workability with different percentages of sand.
C. Total gallons of water required for a yard of concrete with varying cement content, aggregates and slumps.
D. Strength corresponding to a given slump and water-cement ratio.
E. Shrinkage Factors.

(4) Simple rules of proportioning may be derived from the experience acquired above. These may be based on a modification of the fineness modulus formula for local materials, or, where a deficiency of size in grading occurs, especially in the sand, arbitrary percentages of sand may be determined by experiment.

For a combination of fine and coarse aggregates in a given district, workability without sacrifice of strength or density may be attained by a range in the percentage of sand compared with the total aggregate. The actual amount to use then depends on the relative cost of the aggregates.

Examples in Two Districts

With the factors of cost and workability in mind, the data in Table 1 were determined for a district in which concrete aggregates are notably deficient in the smaller sizes.

TABLE 1—PERCENTAGE OF SAND FOR GIVEN SIEVE ANALYSIS

	Pct. Passing		Pct.	Quantities for one cu. yd.			
Mix	20 mesh	50 mesh	of Sand	Cement lb.	Sand lb.	Gravel lb.	Water gals.
1-2½-5	70-75	10-15	33	448	1,150	2,200	32
	65-70	7-10	35	448	1,225	2,125	32
	55-65	6- 8	38	448	1,300	2,050	32
1-2-4	70-75	10-15	33	535	1,100	2,150	34
	65-70	7-10	35	535	1,200	2,050	34
	55-65	6- 8	38	535	1,250	2,000	34

These figures are applied to a regular set-up where the grading of the materials demands it. Where the resulting mixes were followed up on the job they were observed to result in improved workability.

Table 2 represents part of a complete set-up which covers the range of demand in a given district for mixes and strength concrete. The quantity figures are based on average materials.

TABLE 2—SET-UP FOR TRUCK-MIXED CONCRETE

Kind	Cement	Sand	Gravel	Total Aggregate	Water
2,000 lb.	506 lb.	1,200 lb.	2,050 lb.	3,250 lb.	33 gals.
1-2-4	535 lb.	1,200 lb.	2,050 lb.	3,250 lb.	34 gals.

The complete data, of which a part is shown in Table 2, is blueprinted and is set up on the mixing floor, and is also furnished to the salesmen, insuring that the order as given will go through without mistake. Variations in the grading of materials, as reported by the control laboratory, would modify this set-up, as stated above.

In another district where the fine aggregate is a uniform bank sand having plenty of fines, and the coarse aggregate is stone, the fineness modulus formulas as modified by trial mix experimentation and considerations of strength, workability, and costs, would take care of minor variations in the materials.

With a limited variation in the materials it was found possible to use the same weights of fine and coarse aggregates in a range of mixes varying from 1-2½-5 to 1-2-3½, the only change in the set-up being the weight of cement and the water for the various mixes.

This practice is justified not alone by our own research but by a study of the work of F. R. McMillan and Stanton Walker, presented in their published work on the absolute-volume relations of the constitutents of a unit volume of concrete. This practice reduces the need of an involved floor schedule and thereby lessens chances of error materially and also simplifies accounting, cost and pricing records.

(*To be concluded*)

New Emulsion for Curing Concrete Pavement

A NEW method for curing concrete pavements is described in a recent issue of *Concrete and Constructional Engineering* (London).

The method was applied in the construction of Kingston by-pass road. An emulsion known by the name of "Colas" was applied by a pressure spraying machine and then immediately coated with a thin layer of sharp sand. Quantities employed amounted to 1 gallon of emulsion for each 6¼ sq. yd. of surface, and 1 cu. yd. of sand for each 486 sq. yd. of pavement.

Cores in Reinforced Concrete Piles Formed with Inflated Hose

Missouri Pacific's Experiments Disclose Advantages of Cored Piles—Lighter Weight and Less Material—Large-Diameter Piles to Increase Bearing Capacity

REINFORCED concrete piles with large hollow cores may become an important element in engineering construction work as a result of several experimental piles of this type that were cast and driven by the engineering department of the Missouri Pacific Railway.

Hollow Piles Have Major Advantages

Among the advantages seen in this type of pile are, (1) reduced weight of piles of a given diameter, and greater ease in handling; (2) definite reduction in amount of steel reinforcement; and (3) increased circumference of piles of a given weight, and consequent increase in skin friction.

This third advantage will be of major importance, because of the importance of skin friction in developing the bearing power of piles. For illustration, a 24-in. circular pile with a 10-in. circular core will contain the same quantity of concrete as a solid pile having a diameter of 21.8 in., but the circumference (and consequently the skin friction) of the hollow pile will be 10 per cent greater. Or, if the shell is made 6 in. thick, thus allowing a 12-in. core in a 24-in. pile, the latter will contain the same quantity of concrete as a solid pile 20.8 in. in diameter, and the skin friction will be increased by 15.4 per cent.

In Deep Alluvial Soil

For heavy foundation or trestle construction in deep alluvial soils the advantages of a hollow core become even more evident, inasmuch as hollow piles of large outside diameter will provide the necessary surface area for the development of skin friction in locations where, with ordinary piles, high bearing capacity can not be obtained. Thus, by casting a 30-in. pile with an 18-in. core (maintaining the 6-in. shell thickness), the quantity of concrete in the pile will be the same as in a solid pile 24 in. in diameter, and the skin friction (and the bearing capactiy) will be increased by 25 per cent.

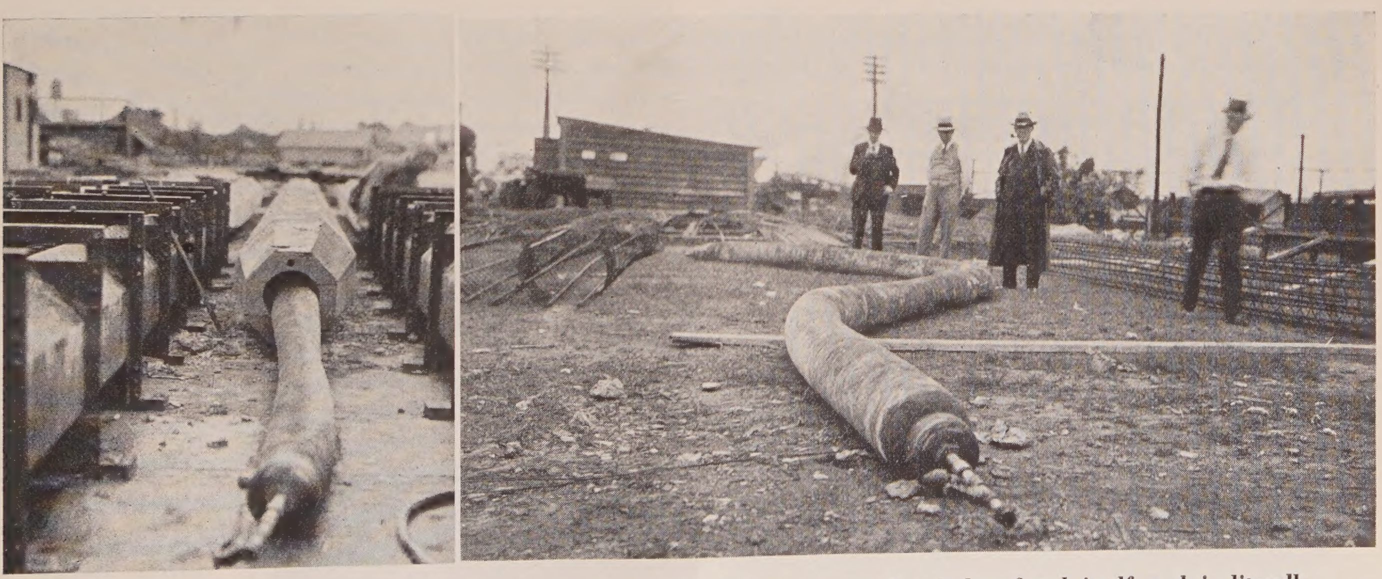
24-Inch Piles with 10-Inch Core

The two hollow reinforced concrete piles cast by the Missouri Pacific Railway were made at the company's yard at Little Rock, Ark., and were driven as a part of the groups in one pier and one abutment of the railway company's new bridge across Prairie du Pont Creek at Dupo, Ill.

Each of these experimental piles, as shown in the illustrations, has an octagonal cross-section with a diameter of 24 in., and a circular core of 10 in. In one pile, which has a length of 36 ft. and was driven as the most westerly in the south abutment, the core extends throughout its entire length, the pile being blunted at the open point. The other cored pile, driven at pier No. 2, has a standard solid point, the core extending throughout the straight shaft.

Pile Heads Not Damaged

Both of the cored piles have the core extending through the butt end, a fact which gave rise to some concern as to how the butts would be affected by driving. However, the presence of the core had no detrimental effect whatever.



At left, the flexible hose that formed the core in the pile has been deflated, has freed itself and is literally "crawling" out. At right, the hose inflated

The pile heads suffered no damage, even though the driving was so hard as to require approximately 150 blows for the last foot of penetration. Pile-driving records were kept of one solid pile and the cored pile in the south abutment, and of the cored pile and two solid piles in pier No. 2.

The driving records show that after the pile with the open point was driven in the south abutment, soil had been forced upward into the core to a depth of 14 ft. 8 in. above the point. This pile drove considerably easier than its neighboring solid pile until the more solid soil strata were reached.

Handling and Driving

Handling of the cored piles was in no sense different from handling of the solid piles. The solid piles have the same diameter as the cored piles—namely, 24 in.—so that the weight of the latter is considerably less. The foreman and other members of the pile-driving crew reacted favorably to the hollow piles, inasmuch as their reduced weight was quite noticeable.

The pile-driving equipment employed was the Missouri Pacific's large pile-driver car, utilizing a No. 0 Vulcan single-acting hammer having a ram weighing 9,000 lb. and a stroke of 4 ft. Cushion blocks used on the cored piles were the same as for the solid piles, and consisted of two layers of gum plank spiked together.

Inflated Tube Forms Core

The cores in these experimental piles were formed by means of a flexible rubber hose which expands under air or water pressure to a predetermined diameter, at the same time decreasing in length. After the concrete had set sufficiently, the hose was deflated. This deflation results in a reversal of the action, the diameter of the hose having been reduced and the length increased. This action caused the hose to free itself from the wall of the core, and literally to "crawl" out, as shown in the illustration at the left. The illustration at the right shows the hose in an inflated condition.

Additional hollow piles of the kind here described have been cast in the yard at Little Rock, and will be driven in another bridge on the Missouri Pacific Lines sometime in August. This next test will be made to verify the facts obtained at Dupo, Ill., and to obtain information which is expected to disclose additional advantages of this type of construction.

Acknowledgments

The flexible, inflated hose employed in the casting of the piles here described was supplied by the Flexicore Company, Wichita, Kans., of which E. R. Rogers is sales manager. F. E. Bates, under whose direction the experimental piles were cast and placed, is assistant bridge engineer for the Missouri Pacific Railway, St. Louis, Mo.

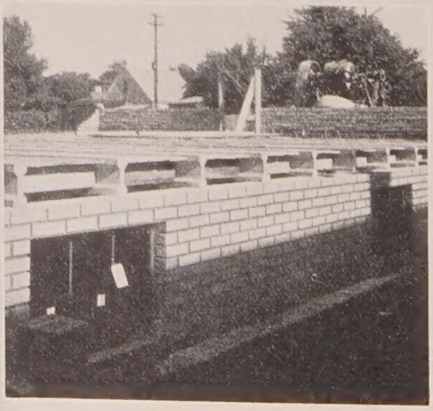
Introduces Precast Concrete Joist Floor by Inviting Inspection

Springfield Products Manufacturer Explains Merits of New Fireproof Floor Construction to Visitors

MUCH interest is being shown in precast concrete joists for residence floor construction in Springfield, Ill., where the first new home in Illinois—in which joists are used—is under construction. It is the home of Charles King, local policeman. It is being built by William Reed, contractor, of Springfield. The precast concrete joists were manufactured by the Standard Concrete Pipe Company under the direction of W. S. Gearhart, manager.

Approximately 50 people accepted an invitation to inspect the construction on a recent Sunday. They braved torrid weather—contractors and laymen alike—to see something new and practical.

One of the accompanying photographs shows a closeup of the joist construction, with the joists, spreaders and form boards in place, ready for the contractor to place building paper—to form a smooth ceiling between joists—and the steel to reinforce the slab. The other shows a number of contractors talking to Mr. Gearhart (second man from the left) about the possibilities of precast joists on other residence jobs, as the latter explains the merits of this newest type of fireproof floor construction.



Left: Talking concrete joists to visitors. Right: A closeup of the precast joist construction with joists, spreaders and form boards in place

Chemical Composition of Cement Told in Non-Technical Language

Fineness in Terms of Specific Surface—Other Trends in Use and Manufacture of Cement

By J. C. WITT

This article was written at the request of the editor of the Chemical Bulletin, the monthly publication of the Chicago Section of the American Chemical Society, and appeared in the June issue. The object was to present a few fundamental facts about cement to readers who are not associated with the cement industry. With the idea that some readers of "Concrete," who are users of cement, may be interested in reading the paper, we requested permission from the editor of the Chemical Bulletin to reprint the paper.—Editor.

THE cement industry belongs to a group of industries, the foundations for which were laid in advance of modern science and technology. Portland cement has been manufactured for more than a century, being evolved from cements, and plastics in general, known many centuries ago. The nature of the present day product is due to developments in chemistry and other sciences, and the application of these developments to the industry. Mechanical engineering and electrical engineering have been very important factors in providing plant equipment and power generation. It has been pointed out previously that the industry is a typical chemical engineering industry. Raw materials must pass through chemical changes to be transformed into the finished product. In fact, every step in the manufacturing process involves chemical change or the preparation for chemical change.

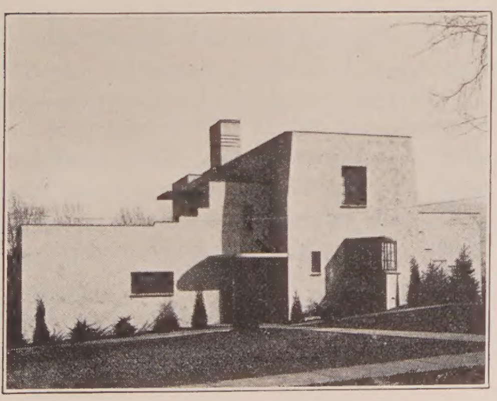


Figure 1—The House of Tomorrow, Omaha, Nebr., built by the Omaha Junior Chamber of Commerce. The walls above grade are of cinder concrete masonry, which is coated with lightly colored and textured portland cement stucco

Chemical Control

Previous to about 1756, cement was manufactured by the trial and error procedure. In that year, a chemical control method was employed for the first time. Limestone samples were treated with nitric acid and the weight of the insoluble residue provided a basis for selecting suitable stone. As crude as this method was, it proved to be of great importance in the development of the industry. The work of Le Chatelier placed the industry on a scientific basis. The present era may be said to have started with some researches at the Geophysical Laboratory at Washington, D. C.

Portland cement clinker consists principally of four synthetic minerals; tricalcium silicate ($3CaO.SiO_2$), dicalcium silicate ($2CaO.SiO_2$), tricalcium aluminate ($3CaO.Al_2O_3$), and tetracalcium alumino ferrite ($4CaO.Al_2O_3.Fe_2O_3$). When clinker is ground to produce portland cement, a small quantity of gypsum is added for controlling the time of set. This is a special rather than the official definition of the material and it has been employed here because it serves the purpose better than the definition regularly in use.

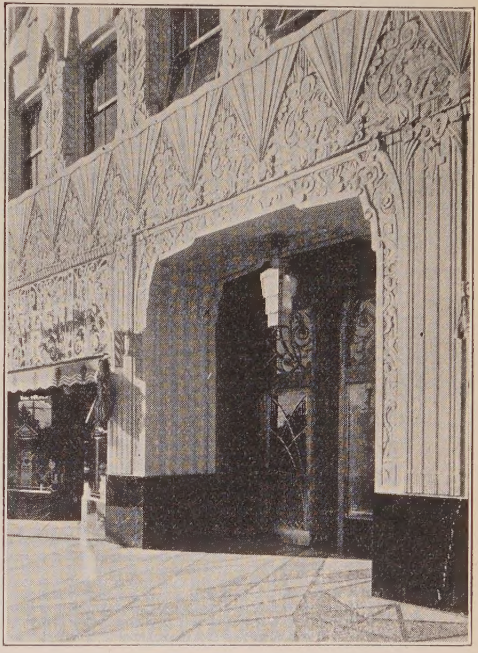


Figure 2—Wilshire Professional Building, Los Angeles, Calif. This is monolithic concrete construction. All ornamental concrete was cast in place in plaster waste molds

Just a few points have been selected for brief discussion as examples of present trends in the industry. These are fuel conservation, cement composition, and cement specific surface.

Fuel Costs

When the rotary kiln first came into use about forty years ago, it brought with it improvement in the quality of the product and decrease in labor costs—but an increase in fuel costs. Fuel conservation at once became a problem of major importance in the industry, and has remained so to the present. Many investigations have been made and the literature on this subject is extensive.

Among the measures that have been tried commercially in the interest of fuel economy, there may be mentioned modifications in kiln design, kiln insulation, waste heat boilers, preheating of the kiln feed, and preheating of the primary and secondary combustion air. One of the most important and most extensively used, of these, is the waste heat boiler.

Composition

Although the complex nature of cement has been known for many years, it has been considered, in effect, a single material such as brick, building stone, and the like. At present, however, there is a tendency to take into account the four synthetic minerals individually. Information on simple procedures for calculating the approximate percentages of these minerals has been broadcast. Although they are not manufactured and marketed separately, the characteristics of each are becoming well known through a series of published papers and reports before technical societies during the last few years. For some large projects, special cements have been specified on the basis of mineral composition.

Specific Surface

An important characteristic of cement is the fineness of grinding. Fineness is expressed in terms of the percentage passing a 200-mesh sieve. It has been known for many years that this is not a true indication of particle size. Procedures have been developed for separating cement into various size fractions, such as 0-5 microns, 5-10 microns, and so on. Also, equipment is available by which the specific surface may be estimated, in square centimeters per gram.

The Nature of Clinker

In a recent paper, Fisk discusses the nature of portland cement clinker, and modern methods of research as applied to its study.

"Fundamental equilibrium studies on the systems lime-silica, and lime-alumina-silica, have shown what compounds are possible in portland cement clinker. Petrographic and X-ray studies have proved the existence of these compounds in commercial cement clinkers. Synthetic studies on the pure compounds and mixtures of them have indicated their functions in portland cement. The principles of phase equilibria as applied to the portland cement regions of the lime-silica and the lime-alumina-silica systems are briefly reviewed. The application of thermo-chemical, petrographic, and X-ray crystal analysis methods to the solution of the problem of the constitution of portland cement clinker is indicated."

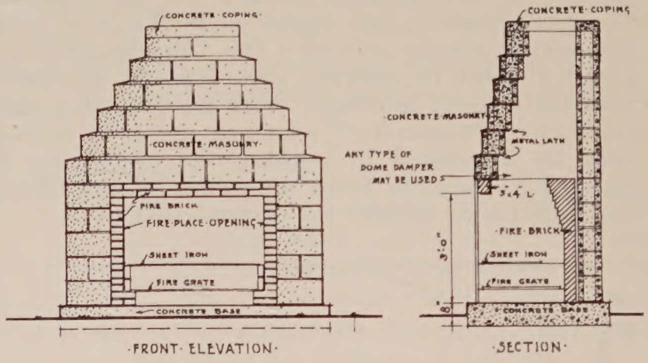
Recent Trends in Application

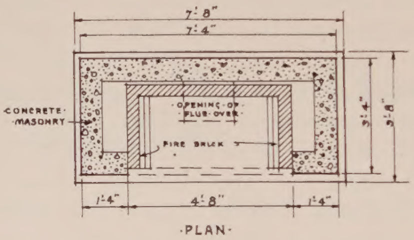
Formerly concrete was generally considered as a structural material only. That is, concrete was accepted as highly satisfactory for providing structural strength, but it must be covered by some other material where decorative features were desired. It is now recognized that concrete has beauty as an architectural material; and many structures of all types, from dwellings to skyscrapers, have demonstrated this. The figures show examples of modern structures in which concrete provides decoration as well as structural strength.

Attractive Outdoor Fireplace of Concrete Masonry

CONCRETE contractors wishing to add outdoor fireplaces to their list of special construction work may obtain plans and complete information on construction, including a bill of material required, by writing to the Portland Cement Association.

The concrete masonry fireplace here illustrated will require 90 concrete building units of the 8 by 8 by 16-in. size, and 10 units of the 8 by 8 by 8-in. size. About 225 fire brick will also be required. One steel angle, 3 by 4-in., 5 ft. 2 in. long, will be needed to place over the fireplace opening. For the mortar to lay up the concrete units and fire brick the contractor will need one sack of portland cement, 20 lb. of hydrated lime, and 4½ cu. ft. of mortar sand.





Outdoor fireplace provides attractive and useful addition to parks, picnic grounds, tourist camps, or to private playgrounds

The concrete mixture for the base should be a 1-2¼-3 mixture of cement, fine aggregate, and coarse aggregate.

A similar fireplace may be built of monolithic concrete. The mixture may be 1-2¼-3, as for the concrete base. Walls should be made not less than 6 in. thick at any point, and should be reinforced with ¼-in. steel bars spaced 12 in. apart and placed both vertically and horizontally. Or, instead of the bars, a welded wire fabric having an equivalent cross-section may be employed.

Coming Conventions

***September 24-28*—American Society of Municipal Engineers. Annual Meeting. Rochester, N. Y.**

***December 6-7*—Highway Research Board, National Research Council. Fourteenth Annual Meeting. Roy W. Crum, Director, 2100 Constitution Avenue, Washington, D. C.**

1935

***February 19-21*—American Concrete Institute. Thirty-First Annual Convention. Roosevelt Hotel, New York City. Harvey Whipple, Secretary, 7400 Second Blvd., Detroit, Mich.**

◆ EDITORIAL ◆

Home Building Under the Housing Act

THE past five years of discouragement may have dulled the sensibilities of the construction industry to the point where the great possibilities lying in the National Housing Act have not been appreciated.

This Act, passed in the last days of the Congressional session and signed by the President on June 28, is designed to start early revival of the construction and the durable goods industries. Two results are sought — widespread modernization and repair of homes and other buildings, and a revival in the building of new homes.

Immediate efforts are being concentrated on the repair and modernization phase, since this type of work can be started most quickly. As soon as the modernization phase is in smooth operation, attention will be given to the resumption of construction of new homes.

The National Housing Act does not contemplate direct loans to home owners, except through the HOLC on distressed property. The purpose of the Act is that of making private loans an attractive investment. This is accomplished through the five principal features of the law.

First, there is the insurance feature, covering 20 per cent of the principal amount of the loan.

Second, the Act insures 100 per cent of the principal of amortizing first mortgages for new homes. Construction loans may amount to 80 per cent of the appraised value of the property.

The third feature is the creation of national mortgage associations to attract private capital to areas lacking adequate mortgage credit.

The fourth feature is the insurance of individual investors' accounts in building and loan associations, up to $5,000.

Fifth, we have the increase in capitalization of the HOLC.

In a word, the National Housing Act sets up a national plan for the financing of prospective home owners on a basis that avoids the pawn-shop methods of the post-war period. It may easily develop into a settled national policy.

Vault Manufacture a Growing Industry

IT is highly significant that during the last three or four years, when the volume of production of almost every article of commerce was on the decline, the production of concrete burial vaults was in an upward trend.

Without fear of contradiction it may be said that many a manufacturer of concrete products found his salvation in the manufacture of vaults. He may have suffered some reduction in sales, and he may have been compelled to reduce prices to the point where little or no profit remained; but this part of his business kept his plant at least in partial operation.

Contractors, also, have turned in increasing numbers to the manufacture of concrete burial vaults. With construction contracts few and almost impossible to obtain on a profitable basis, scores of contracting concerns were able to put a part of their concrete-making equipment to work in the production of vaults. Many new market areas were opened up in this manner.

Doubtless a part of the increase in the production of concrete burial vaults has been due to these new plants in new territory. But there are other reasons —the principal reason, in all probability, being the undeniable fact that the public prefers concrete vaults wherever they are produced under proper manufacturing conditions and merchandised with intelligence.

An inkling of the vastness of the market in this field may be obtained from the article entitled "Prospective Market for Concrete Burial Vaults," printed on page 18 of the June (1933) issue of "Concrete." The same article discloses the high percentage of sales in sections comprising the trade areas of competent and aggressive manufacturers.

The concrete burial vault industry has far greater possibilities than the present development of the market indicates. Many good markets remain untouched. In consequence, it behooves newcomers in this field to establish their plants in new territory, instead of attempting to divide the business of an existing plant.

Pollution of Streams Can Be Stopped

TRAVELERS have observed with unpleasant frequency the distressing condition of many beautiful streams, which have become little more than open sewers as a result of the low-water stages caused by the drought and the unending streams of untreated sewage that is being dumped into them.

A recent trip along one of the most beautiful of the smaller rivers of Michigan — a stream that flows through several cities of considerable size—disclosed the present situation in all its ugliness. For some miles below each of the larger cities one could see islands of dried sludge floating along on the surface or blocked temporarily at bridges. The water, once clear in times past, was unfit to sustain aquatic life.

There is only one cure for such conditions—the construction of sewage disposal plants. That cure must be applied sooner or later.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Cottonseed Hulls and Asphalt as Joint Filler

AN unpublished report of the South Carolina State Highway Department, Columbia, S. C., dated April 17, 1934, is mentioned in the July (1934) issue of *Highway Research Abstracts,* Washington, D. C.

Early in 1931, the report states, the department filled the joints on a 5-mile section of pavement, using some 34 different fillers, including asphalts and tars, mixtures of asphalts, tars and asphalt emulsions with sawdust, cork, stone dust and cottonseed hulls. After regular inspection during 1931 and 1932 a few of the best fillers were selected and used on another section of 14 miles in February, 1933. In February, 1934, the department selected as the best filler one which consisted of 50 per cent cut-back asphalt and 50 per cent dried cottonseed hulls, by volume (1½ to 3 lb. of hulls to 1 gallon of cut-back asphalt). This filler gave excellent results. It was adhesive and elastic in cold weather and did not run out of the joints in warm weather. The report contains the specifications covering the asphalt, flux and cottonseed hulls.

Foreign Standards

THE American Standards Association announces that it has the following foreign standards available for distribution:

From Holland:

559. Aluminum cement, definitions and testing requirements.

560. Blast-furnace cement, definitions and testing requirements.

561. Iron-portland cement, definitions and testing requirements.

562. Portland cement, definitions and testing requirements.

From England:

591. Precast concrete partition slabs (solid).

The above standards are printed in the language of the country named. Request for copies should be addressed direct to the American Standards Association, 29 West 39th Street, New York, N. Y.

Large-Scale Housing Plans

THE recent May issue of *Building Science Abstracts* (London) refers to a German-language bulletin on slum clearance and improved housing for low-income groups. The bulletin is entitled "Building Research—Final report on the experimental housing schemes at Frankfort-on-Main-Praunheim and Westhausen (Bauforschungen—Abschliessender Bericht über die Versuchssiedlungen Frankfurt a. Main-Praunheim und Westhausen)," in which a detailed report is presented on extensive studies carried out in connection with two large German housing schemes, in which the buildings were constructed of pre-cast pumice concrete and other light-weight concrete units manufactured in a central factory. The report summarizes at considerable length the experience gained in the planning and laying out of such schemes, and in the design of the most suitable types of buildings and flats as regards the comfort and health of their occupants. In addition, a mass of information is presented on the results obtained in investigations of the properties of the various elements used in the construction of the buildings. Slabs of various types were tested for moisture content, moisture movements, strength, heat-insulating properties, and other important characteristics. Voluminous data are also presented on the costs, the design, the construction methods and the behavior of the buildings in use. Several references are given to other published descriptions of the work carried out on these housing schemes.

Standard Building Code for Cities of New York

THE New York State Department of Labor, in collaboration with the conference of mayors and other municipal officials of the State, and the college of engineering of New York University, is beginning a technical study of all building codes of the state for the purpose of unification and standardization and an ultimate recommendation to the legislature for the adoption of a state standard building code.

The project, as described in a statement issued by William L. Picard, deputy commissioner of labor of the State of New York, will be developed by engineers, architects, and statisticians under the CWA with offices in the school of architecture of New York University.

Architectural Details of Cast Stone

A FOLDER of technical data and architectural detail sheets on cast stone has been issued by the Cast Stone Institute, 33 W. Grand Ave., Chicago. This is the first material of its kind ever published on this subject. Architects and draftsmen will find it interesting and useful as a source of impartial and reliable information on cast stone. Copies will be supplied free, on request, while they last.

For Study of Vibrated Concrete

THE U. S. Bureau of Standards, Washington, D. C., has developed and built a machine for making a study of vibrated concrete specimens. By vibration, concrete with a selected low water-cement ratio has twice the strength of, as well as greater density than, hand-placed concrete using approximately the same quantities of material.

The Analysis of Fresh Concrete

Concluding Installment Describes Test Procedure in Determining Correction Factors Due to Grinding Action of Concrete Mixing Process

By WILLIAM A. BLANCHETTE
Highway Engineer, Division of Management, U. S. Bureau of Public Roads

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This is the concluding installment of a series of three, beginning in the June issue. In this part the author shows how to determine correction factors due to the grinding action of the concrete mixing process, when, in effect, the mixing drum acts as a ball mill.—Editor.

GRINDING may or may not take place during the mixing. The extent of grinding is probably regulated by some or all of the following factors: type and gradation of both fine and coarse aggregate, proportion of each in mix, number of revolutions of mixer drum, ratio of capacity of mixer drum to volume of batch, type of mixing action in drum, including the amount of drop of the aggregates.

Determining Correction Factors for the Grinding Action

There is no way definitely to determine the amount of grinding that takes place during the mixing of a batch of concrete. Even though the entire batch could be analyzed to determine the actual amount of material finer than the No. 100 sieve after mixing, the corrections for the amounts of each ingredient passing this sieve before the mixing must be applied. These corrections may not be exact, since they are based on samples that are only a small part of the ingredients in the batch.

The existence of grinding is indicated when the analysis of the samples shows a consistent plus quantity for the cement after all other correction factors have been applied. Should this condition exist, the grinding is investigated and a correction factor determined for the percentage of both coarse and fine aggregate so reduced in size during the mixing action that it passes the No. 100 sieve.

Determination of Grinding Action

In this particular analysis the grinding action was investigated in the following manner: A quantity of coarse aggregate and a quantity of water equal to the proportions of these ingredients in the batches being sampled were charged into the mixer. At the end of one, two, three and four minutes of mixing a 30-lb. sample of coarse aggregate was removed from the mixer and washed in the washing machine. The percentage of aggregate passing the No. 100 sieve was determined. The test was repeated with fine aggregate and water, and then with fine aggregate, coarse aggregate and water. Several determinations were made with each combination.

The results of these tests in this analysis showed that for the coarse aggregate and water mixture there was no appreciable amount of grinding for any mixing period used. The same was true for the fine aggregate and water mixture; but for the fine and coarse aggregate and water mixture the amount of aggregate passing the No. 100 sieve, in excess of that passing before entering the mixer, was appreciable and increased with the length of the mixing period.

It was assumed from this test that the mixer drum acted as a ball mill, and that the particles of sand were pulverized by the particles of coarse aggregate falling on them. There appeared to be no pulverizing of the fine particles of coarse aggregate by the larger particles, and there appeared to be no wearing away of either aggregate due to friction with the drum, blades, and buckets.

Check Tests of Grinding Action

As a further check in establishing the grinding action factors, the following procedure was followed: The analysis of every sample of concrete showed the percentage variation (plus or minus) of the cement, fine and coarse aggregate and water from the actual batch proportion of each of these ingredients. The complete analysis of all samples for all mixing periods showed a consistent plus variation for what was called cement, and a consistent minus variation for fine aggregate. There was no evidence in these analyses that the coarse aggregate was ground up to pass either the No. 4 or No. 100 sieve.

From the average of all variations in cement and all variations in fine aggregate for each mixing period, the apparent gain in cement due to grinding of fine aggregate was computed for each of these mixing periods. Correction factors as computed in this manner checked closely with those determined from the method previously outlined. The average of the factors determined by both methods was then applied in recomputing the variations in all samples. These correction factors for this particular analysis were as shown in Table 2.

TABLE 2—PERCENTAGE OF SAND GROUND TO PASS No. 100 SIEVE

Mixing time in minutes	Correction factor in per cent
1	2.5
2	2.9
3	3.7
4	6.0

Following is an example of procedure and computations connected with the analysis of one of the five 30-lb. samples removed from the batch of concrete.

Weight of sample in air	30.00 lb.
Weight of sample immersed in water	17.42 lb.

After the immersed weight was obtained the sample was placed in the washing machine and all material passing the No. 100 sieve was washed out. By shaking the drum of the machine the aggregates in the drum were separated by the No. 4 sieve and the following immersed weights were obtained:

Weight of aggregate retained on No. 4 sieve	9.36 lb.
Weight of aggregate passing No. 4 sieve and retained on No. 100 sieve	5.33 lb.
Weight of material passing No. 100 sieve (difference)	2.73 lb.

The estimated proportion of aggregate retained on the No. 4 sieve to the total gravel was:

Loss to cement	0.5 per cent
Loss to sand	2.2 per cent
Loss from gravel	2.7 per cent
Gain from sand $= 8.1 \times \left(\frac{4465^{*}}{5757^{**}}\right)$	6.3 per cent
Net gain to gravel (gain on No. 4 sieve)	3.6 per cent
Aggregate retained on No. 4 sieve as a percentage of the gravel	103.6 per cent

The estimated proportion of the aggregate passing the No. 4 sieve and retained on the No. 100 sieve to the total sand was:

Initial loss to cement	1.8 per cent
Loss to cement by grinding (1 min. mix)	2.5 per cent
Loss to gravel	8.1 per cent
Total loss from sand	12.4 per cent
Gain from gravel $= 2.2 \times \left(\frac{5757}{4465}\right)$	2.8 per cent
Net loss from sand (loss on No. 100 sieve)	9.6 per cent
Aggregate passing No. 4 sieve and retained on the No. 100 sieve as a percentage of the sand	90.4 per cent

Applying the correction factor for the total amount of gravel—

Total under-water weight of gravel:

$$= 9.36 + 0.5 \times \left(\frac{9.36}{103.6}\right) + 2.2 \times \left(\frac{9.36}{103.6}\right) - 8.1 \times \left(\frac{5.33}{90.4}\right)$$

$$= 9.36 + 0.05 + 0.20 - 0.48 = 9.13 \text{ lb.}$$

Applying the correction factors for the total amount of sand—

Total under-water weight of sand:

$$= 5.33 + 1.8 \times \left(\frac{5.33}{90.4}\right) + 2.5 \times \left(\frac{5.33}{90.4}\right) + 8.1 \times \left(\frac{5.33}{90.4}\right) - 2.2 \times \left(\frac{9.36}{103.6}\right)$$

$$= 5.33 + 0.11 + 0.15 + 0.48 - 0.20 = 5.87 \text{ lb.}$$

NOTE: * Immersed weight of fine aggregate in total batch.
** Immersed weight of coarse aggregate in total batch.

Applying the correction factors for the total amount of cement—

Total under-water weight of cement:

$$= 2.73 - 0.5 \times \left(\frac{9.36}{103.6}\right) - 1.8 \times \left(\frac{5.33}{90.4}\right) - 2.5 \times \left(\frac{5.33}{90.4}\right)$$

$$= 2.73 - 0.05 - 0.11 - 0.15 = 2.42 \text{ lb.}$$

The bone-dry weights in air are:

Gravel $= 9.13 \times \left(\frac{2.66}{1.66}\right)$	14.63 lb.
Sand $= 5.87 \times \left(\frac{2.68}{1.68}\right)$	9.36 lb.
Cement $= 2.42 \times \left(\frac{3.17}{2.17}\right)$	3.53 lb.
Total weight of solids	27.52 lb.
Total weight of water (difference)	2.48 lb.
Total weight of sample	30.00 lb.

The correction for the water absorbed by the aggregates was:

Absorbed water in sand $= 0.005 \times 9.36 =$	0.05 lb.
Absorbed water in gravel $= 0.003 \times 14.63 =$	0.04 lb.
Total absorbed water $=$	0.09 lb.
Free water $= 2.48 - 0.09 =$	2.39 lb.

The variation in the amount of each ingredient in this particular sample from the amount of the ingredient that went into the batch as a whole was as shown in Table 3.

TABLE 3—VARIATION IN INGREDIENTS AFTER MIXING

Material	Batch weights of 30 lb. sample proportionate to total batch weights (Pounds)	Weights in Sample "A" (Pounds)	Percentage variation from total batch proportions
Gravel	13.45	14.63	+ 8.8
Sand	10.39	9.36	— 9.9
Cement	3.39	3.53	+ 4.1
Free water	2.68	2.39	—10.8
	29.91	29.91	
Absorbed water	0.09	0.09	
Total	30.00	30.00	

A similar analysis was made on each of the five samples removed from each of twenty-four different batches of concrete in order to determine the uniformity with which the batches were mixed for each of the four mixing periods. By designating variations as plus and minus the spread in the uniformity of distribution of each ingredient in each batch was determined.

The example given is but one of the many problems in concrete research to which this method of analyzing fresh concrete to determine its constitutents can be applied.

Calculating Heat Generated During Hardening

A METHOD has been developed by D. Werner (Germany) for the calculation of heat generated by concrete during hardening.

Tables show the heat developed during different periods of time by the tricalcium aluminate, tricalcium silicate, brownmillerite and dicalcium silicate forming the principal components of portland cement clinker, the heat developed or absorbed by the lime, silica, ferric oxide and alumina as determined by chemical analysis of the clinker, and also a nomogram for calculating the maximum rise in temperature in concrete for different mixing ratios and water-cement ratios, when the heat developed by the cement is known.

This nomogram is based on the equation $t_{\max} = w\,(0.183 + v + 0.20\,n)$ in which w is the heat developed per kg. of cement measured in kilogram calories, 0.183 is the specific heat of the cement, v the water-cement ratio, 0.20 the specific heat of the sand and stone aggregate, and n the number of parts, by weight, of aggregate to one part of cement.—*Building Science Abstracts* (London).

Determining Heat of Hydration with Dry Sample of Cement

Method Prescribed by U. S. Bureau of Reclamation in Specifications No. 566 for Boulder Dam Cement

IN the May (1934) issue of CONCRETE, pages 15 and 16, appears an article giving the chemical and physical properties of the cement specified for use in Boulder Dam, as prescribed in the schedule and specifications issued by the United States Bureau of Reclamation in that Bureau's invitation for bids to supply cement for this project.

The specifications set definite limits on certain of the compounds of cement, the purpose being that of obtaining a slow-hardening cement—with the consequent result that generation of heat during hardening will be at a low rate.

How Heat of Hydration Is Determined

This question of determining the "heat of hydration," or the quantity of heat generated within a given period of time, is one of growing importance. Users of cement, more especially those who may be classed as cement chemists and concrete technologists, are showing a greater interest in the compound composition of cements, and in the methods employed in determining such properties as the heat of hydration. For this reason, this group of readers will be interested in the method specified by the United States Bureau of Reclamation in its invitation for bids, mentioned in the first paragraph of this article. The method follows:

(A) *Determination.*—Three hundred grams of cement and 120 grams of distilled water shall be mixed together and vigorously stirred with a mechanical stirrer for five minutes, after which a representative portion shall be used to fill four* or more homeopathic vial containers (¾ x 4 in.) in approximately equal amounts. The temperature of the materials shall be regulated, commensurate with mixing-room temperature, so that the temperature of the cement paste shall be 70 deg. F. (± 5 deg. F.). The vials shall be sealed immediately upon filling with a tightly fitting cork which in turn shall be coated with paraffin. The vials shall be stored in a vertical position for the first 24 hours at 70 deg. ± 1 deg. F. and then at 100 deg. ± 1 deg. F. until the samples are tested. At each of the ages of 7 and 28 days, the heat of solution of one specimen of the partially hydrated cement in a given acid mixture shall be determined. One determination of the heat of solution of the dry cement in an identical acid mixture shall also be made not later than the date of the 7-day test on hydrated cement. The heat of hydration at the age of 7 days shall be determined by subtracting the heat of solution of the specimen of cement, which has hydrated for 7 days, from the heat of solution of the corresponding specimen of dry cement tested. Similarly, the heat of hydration at the age of 28 days shall be determined by subtracting the heat of solution of the specimen of the cement which has been hydrated for 28 days from the heat of solution of the specimen of dry cement. The heat of solution of a cement sample, either dry or partially hydrated, shall be determined by dissolving a known weight of the cement in a dilute nitric-and-hydrofluoric-acid mixture and by observing the resultant temperature rise. Sufficient data shall be obtained to make corrections to the observed temperature rise for all loss or gain in heat due to other causes than heat of solution. From the corrected temperature rise and other necessary data, the heat of solution of the sample shall be computed and expressed in calories per gram of the cement on an ignited weight basis. The entire testing procedure shall be conducted with such accuracy that two determinations of heat of solution upon companion specimens will check each other within three calories per gram of cement.

Dry Cement Sample

(B) *Heat of Solution Test on Dry Cement Sample.*—The apparatus shall be so designed as to give an accuracy of 1 part in 1,000 in the determination of the heat of solution. The equipment and test procedure shall be as follows:

(1) Equipment:

(a) *Calorimeter Proper.*—The calorimeter shall consist of an outer vessel holding in position an inner or reaction vessel, which in turn contains the acid mixture, electric heater, stirrer, platinum resistance thermometer and bakelite valve for introducing the cement sample into the acid mixture. The details of these parts of the calorimeter and other accessories shall be as follows:

1. The inner vessel, of brass, gold plated on the inside and chromium plated on the outside, shall be cylindrical in shape with hemispherical bottom and shall have a capacity of 650-700 ml. It shall be polished on the outside and coated on the inside with an acid-resisting material such as beeswax, bakelite or stonite.
2. The brass cover for the inner vessel shall be chromium plated and polished on the outside, coated with the acid-resisting material on the inside, shall hold the introductory valve and heating coil and shall be provided with openings for the platinum resistance thermometer and stirrer.
3. The electrical heating coil shall be made of manganin wire, have a resistance of 70 to 80 ohms, but known to within 0.01 ohm. This coil shall be housed between two concentric brass cylinders which in turn shall be coated with the acid-resisting material. The leads shall be of copper (not less than B. and S. No. 24) and shall be silver soldered to the manganin wire. The heater assembly shall act as a stirring sleeve.
4. The introductory valve (approximately 10 ml. capacity) shall be made of clear bakelite, cylindrical in shape, and shall have a properly seated valve stem held in place by a spring.
5. The outer vessel, of brass chromium plated and polished on the outside, shall be cylindrical in shape with hemispherical bottom and of such size as to provide an air space of 12 mm. between the walls of the inner and outer vessel. Bakelite points attached to the outer vessel shall maintain this spacing.
6. The removable watertight brass cover for the outer vessel shall be chromium plated and polished. This cover shall be provided with four chimneys which serve respectively for admitting the stem of the platinum resistance thermometer, for providing an exit for the copper heater leads, for housing the stirring shaft and for holding the bakelite push rod used to release the sample from the introductory valve.
7. The stirring of the calorimeter shall be effected by means of a 1/20 hp. synchronous motor connected to the stirrer with a belt.

(b) *Water Bath.*—The water bath of not less than 30 gallons capacity shall be provided with a stirrer, heater, and thermo-regulator for maintaining the desired temperature with an hourly variation of not more than 0.01 deg. C. A Beckman thermometer shall be used to measure temperature variation.

(c) *Apparatus for Determining Heat Capacity.*—The apparatus for determining the heat capacity of the calorimeter shall consist of a heater coil [See (B), (1), (a), 3], sufficient storage batteries to provide a potential of 30-35 volts and capable of delivering a current through the heater varying not more than 0.02 per cent for a 15-minute period, a standard 1-ohm resistance, a precision potentiometer, galvanometer, and a calibrated precision 1/10th second stop-watch. The stop-watch shall be provided with an automatic starting and stopping switch.

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*This number provides for two companion specimens, over and above normal requirements, to allow for rechecking, breakage, etc.

(d) *Apparatus for Measuring the Temperature Within the Inner or Reaction Vessel of the Calorimeter.*—The apparatus shall consist of a calibrated platinum resistance thermometer, Mueller temperature bridge, high sensitivity galvanometer and mercury commutator.

(2) Test Procedure:

(a) *Determination of the Heat of Solution.*—The procedure in making a heat of solution determination on a dry cement sample shall be as follows: The cement shall be removed from its sealed container, and thoroughly rolled, and a representative portion consisting of at least ten grams shall be placed in a weighing bottle. An amount of 3 grams of cement to be herein designated as the calorimeter sample, is then weighed by difference into the introductory valve. An additional amount of 2 to 3 grams of cement, the exact weight being accurately determined and recorded, shall be removed from the weighing bottle and placed in a platinum crucible for determination of loss on ignition. Into the inner vessel shall be placed 640 g. of 2.500 ± 0.002 normal nitric acid and 10.0 ml. of pure hydrofluoric acid, the whole being at a temperature at least 1.8 deg. C. below water-bath temperature.

The inner vessel shall then be placed within the outer vessel and the covers placed on the respective vessels. The assembled vessels shall then be placed in the water bath with the chimneys of the outer-vessel cover extending above the water surface. The rotation of the propeller in the inner vessel shall then be begun and continued for the duration of the test. By means of the heater coil the temperature of the acid mixture in the inner vessel shall be raised until it is approximately 1.6 deg. below the temperature of the water bath, at which stage the use of the heater coil shall be discontinued. At least 12 minutes shall then be allowed for temperature flows to become uniform after which readings of the temperature of the inner vessel shall be observed and recorded at intervals of one minute for at least 5 minutes or until constant difference between consecutive readings is attained. The cement shall then be slowly released from the introductory valve into the acid mixture, and temperature readings continued at one minute intervals. The test shall be terminated when the solution of cement is complete, as evidenced by a substantially constant rate of cooling of acid.

The rise in temperature of the acid mixture from the time at which introduction of cement was begun, to an arbitrarily chosen time somewhat later than that at which the solution of cement was complete, shall be computed from temperature determinations and designated as the uncorrected temperature rise. The time during which the uncorrected temperature rise occurs is designated as the elapsed time. The product of elapsed time and mean temperature difference between acid mixture and water-bath shall be determined by area measurements on a time-temperature chart, or by other methods of integration. Making use of the observed rate of heating of the acid before cement has been introduced and the observed rate of cooling of acid after solution of the cement has been completed, coefficients of temperature change due to stirring and due to heat transfer to or from the inner vessel, shall be computed. The former coefficient is to be expressed as degrees Centigrade per minute and the latter is to be expressed as degrees Centigrade per minute per degree.

Adjustments shall now be made to the observed temperature rise to correct for heat of stirring and heat transfer. The product of elapsed time and coefficient of temperature change due to stirring provides a correction for the temperature rise due to heat of stirring. The product of mean temperature difference between the acid mixture and water bath, elapsed time, and coefficient of temperature change due to heat transfer, provides a correction for heat transfer to or from the inner vessel.

By applying these corrections to the observed temperature rise, the temperature rise due to heat of solution of the cement shall be obtained. The heat capacity, or the number of calories of heat required to raise the acid solution and calorimeter one degree, shall be determined as specified in (b) below. The total heat of solution due to the dissolving of the cement in the acid solution shall be obtained by multiplying the heat capacity in calories per degree Centigrade by the corrected temperature rise in degrees Centigrade. The heat of solution in calories per gram of cement shall be obtained by dividing the total heat of solution by the weight of the calorimeter sample in grams reduced to an ignited weight basis. The calorimeter sample shall be reduced to an ignited weight basis as specified in (c) below. The water-bath temperatures during a test on a dry cement sample shall be within 0.1 deg. C. of the temperature during a test on a corresponding partially-hydrated sample. Any heat of solution test shall be disregarded if undissolved material in an amount exceeding 0.2 per cent of the calorimeter sample remains in the inner vessel after the test.

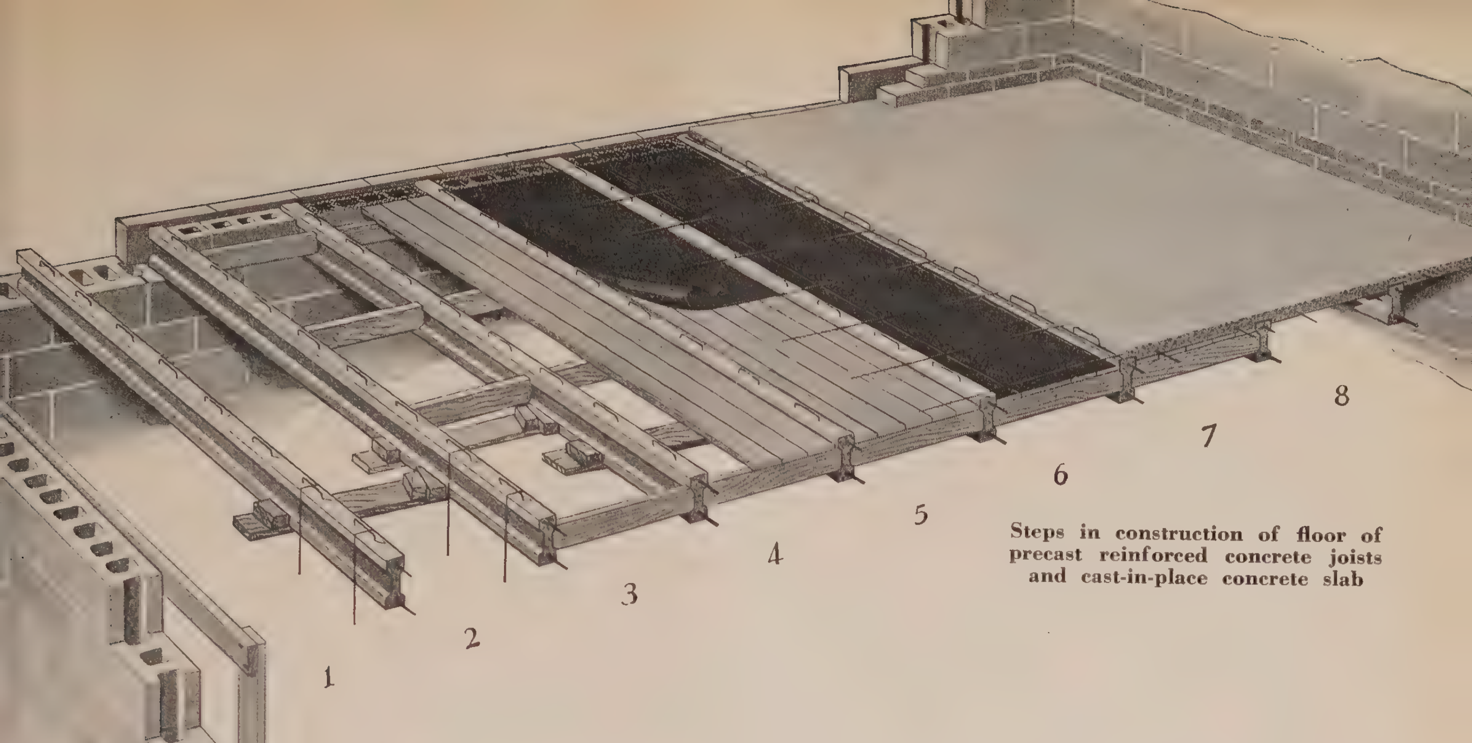
(b) *Determination of the Heat Capacity.*—The procedure for the determination of the heat capacity shall be the same as that outlined in (a) above, except that no cement shall be introduced into the acid solution. Heat shall be added to the acid solution by means of electrical current flowing through the heater coil. The heat added shall be computed from the formula:

$$H = kI^2Rt.$$

where H is the heat added to the solution in calories, k the reciprocal of the mechanical equivalent of heat, I the mean current in amperes flowing through the coil, R the resistance in ohms of the heater coil, and t the time in seconds that the heater current is on. The heat capacity shall be calculated by dividing the heat added in calories by the corrected temperature rise in degrees Centigrade. The output of the batteries shall be stabilized by passing the current through a load coil, the resistance of which is approximately the same as that of the heater coil. The current shall be passed through the load coil for a period of one hour immediately preceding the test, or for such time that the variation of the current shall not be more than 0.05 per cent during a half hour interval. The current shall be started through the heater coil when the temperature of the acid solution is 1.5 deg. C. (± 0.1 deg. C.) below the temperature of the bath, and the heater current shall be shut off when the temperature of the acid solution is 1.5 deg. C. (± 0.1 deg. C.) above the temperature of the bath. At least four readings of the current shall be taken during the test, and the means of these readings shall be the value used in the computations. The time the heater current is on shall be measured accurately with a stop-watch which shall not gain or lose more than one second in two hours. At least two heat capacity determinations shall be made each week, for use in the computations for heat-of-solution tests.

(c) *Determination of Weight of Calorimeter Sample on an Ignited Weight Basis.*—A sample of cement weighing between two and three grams shall be weighed accurately into a platinum crucible. The crucible shall be placed in a muffle furnace at a temperature of 900 deg. C. for 1½ hours. The crucible containing the sample shall then be removed from the furnace, immediately placed in a desecator, and allowed to cool for 15 minutes. The sample shall then be immediately weighed. The ratio of the weight of the ignition sample after ignition to the weight before ignition multiplied by the weight of the calorimeter sample shall be the weight of the calorimeter sample on an ignited weight basis. This ignited weight value shall be used in the computations for determining the heat of solution of the cement in calories per gram.

As stated in the article on chemical and physical properties of Boulder Dam cement, published in the May issue, copies of Specifications No. 566 (for Boulder Dam cement) may be obtained from the United States Bureau of Reclamation, Washington, D. C., while the supply lasts. This printed publication contains, in addition to the specifications here reproduced, specifications and test procedures covering other properties of the cement to be supplied for Boulder Dam. The specifications are the result of tests conducted at the University of California.



Steps in construction of floor of precast reinforced concrete joists and cast-in-place concrete slab

Steps in Constructing Floors of Precast Joists and Slabs

IN an article on pages 13 and 14 of the July issue of CONCRETE, architects and structural engineers were urged to familiarize themselves with the design characteristics and economy of the type of floor construction consisting of a thin slab of cast-in-place reinforced concrete supported on precast joists of reinforced concrete.

As explained in that article, data obtained from tests of this floor construction prove conclusively that a perfect bond is formed between the precast joist and the cast-in-place slab; and that, in consequence, the floor construction may be regarded as belonging to the well-known T-beam type. That article also presents, for the first time, a table of design requirements applying within certain limitations.

Steps in Construction of Floor

As a further means of aiding architects and structural engineers in obtaining a better acquaintance with this type of floor, the detailed drawing here illustrated shows the various steps involved in its construction. Careful study of this drawing, which was prepared by the Portland Cement Association, will result in a full understanding of the sequence of construction and a better appreciation of the possibilities of this type of floor.

The drawing shows what amounts to eight steps in the sequence of construction, the eight steps being illustrated in successive spaces between joists, beginning at the left. These are described briefly in the numbered paragraphs that follow:

(1) The first step consists in the placing of the precast joists, in accordance with the setting plan supplied by the architect or the manufacturer.

(2) Place the braces (usually at mid-span) to stiffen the joists. These braces are shown in the second, third and fourth spaces from the left, where they are seen to consist of short boards with two lugs at each end. A wedge is driven at each end, as shown, to hold the braces in place.

(3) Set the masonry bridging on the foundation wall, between the ends of the joists, as shown in the third space from the left. Also set the spreaders between joists, at intervals of 3 ft. These spreaders consist of short boards with ends cut to fit the outline of the sides of the joists, the ends of the spreaders being supported on the lower flanges of the joists. The purpose of these spreaders is that of supporting the form boards required for placing the reinforced concrete slab. In consequence, the upper edges of the spreaders must be placed at a level such that when form boards are placed, their upper surface will be ½ in. below the top of the precast joists. If a plastered ceiling is specified, place the wire hangers, as shown, to hold the metal lath.

(4) Lay the form boards loose on the spreaders, as illustrated in the fourth space. Box the required openings for service connections. Place small-mesh reinforcement over the hollow spaces if hollow masonry units are used to fill in between ends of joists.

(5) If the underside of the concrete slab is to have a smooth surface (as in cases where no ceiling is to be provided), place waterproof building paper between joists. This is illustrated in the fifth and sixth joist spaces. Or plywood may be used in place of the form boards, if the underside of the slab is to be decorated. When wood floor finish is specified, place sleepers at right angles to the joists.

(6) Place the 2-way steel reinforcement for the concrete slab. The main slab reinforcement is to

consist of ¼-in. round bars spaced 12 in. center to center and placed at right angles to the joists. Tie bars may consist of ¼-in. round bars spaced 18 in. center to center. Or, the steel reinforcement for the slab may consist of welded wire fabric having an effective cross-sectional area equivalent to the ¼-in. round bars here indicated.

(7) Place the concrete, making the slab 2 in. thick if the joist spacing (center to center) is 27 in. or less, and 2½ in. thick if the joist spacing is more than 27 in. and not more than 30 in.

(8) Strip the forms (braces, spreaders and form boards) after the concrete slab has been moist-cured for a period of 5 to 7 days.

From the foregoing it will be seen that no shoring of any kind is necessary to support the form boards. All form work, as well as the freshly-placed slab, is supported by the precast concrete joists until the slab has hardened to the point where it begins to take its share of the load.

Another great advantage, often pointed out in previous articles, is that the construction procedure is not radically different from that to which the average builder of small or light-load buildings is accustomed. And, as was emphasized in the July (1934) issue of CONCRETE, pages 13 and 14, this type of floor construction need not be limited to dwelling houses. It is suitable for any buildings designed for light or medium floor loads, as well as for remodeling work. Where floor loads are heavier than that assumed in the table on page 14 of the July issue, just mentioned, or where the spans are greater or less than the spans included in that table, special designs must necessarily be made.

Standardize Highway Maintenance Cost Data

Bureau of Public Roads Obtains Co-operation of State Highway Departments—Large Mileage Selected for Study

THE July issue of *Highway Research Abstracts* contains the essentials of a report prepared by H. K. Bishop, chairman of the subcommittee on maintenance costs of the Highway Research Board, Washington, D. C., in which the author describes the work thus far accomplished in gathering highway maintenance cost data on a uniform basis of comparison.

A progress report was made by the committee in 1930, describing the ramifications of the problem of collecting accurate maintenance cost data which would be available for comparisons. The variable factors entering into costs made it apparent that in studies of State maintenance, the States must first be divided into groups having similar conditions. The report stated that the Bureau of Public Roads had established a section to study maintenance and to determine, if possible, the relation between costs and other factors. To obtain comparable data, a nation-wide survey will be necessary, relying upon State Highway Departments for collection of comprehensive information. The scope of the study, with difficulties of collection and compilation of reliable data, will perhaps require several years before concrete information can be published.

This report is a description of the progress being made by the Bureau of Public Roads in the study of maintenance costs, since the facilities at the disposal of the subcommittee are largely those offered by the Bureau.

Because of unreliable existing cost data, the Bureau requested the States to select special sections of highways for detailed accumulation of accurate data. These data are recorded and submitted annually in a uniform manner on forms supplied by the Bureau. The States were requested to submit about 20 sections of various types of modern design, well distributed throughout the State, and which will probably remain the same type for a number of years, and on which the amount and kind of traffic is known.

Twenty-eight States have selected their sections and are working on the study. Two States have selected sections for approval. Twelve States are favorably inclined but have postponed definite action. Six States have, so far, declined to make the study.

Following is a general classification of the types of surfaces with mileages selected by thirty States:

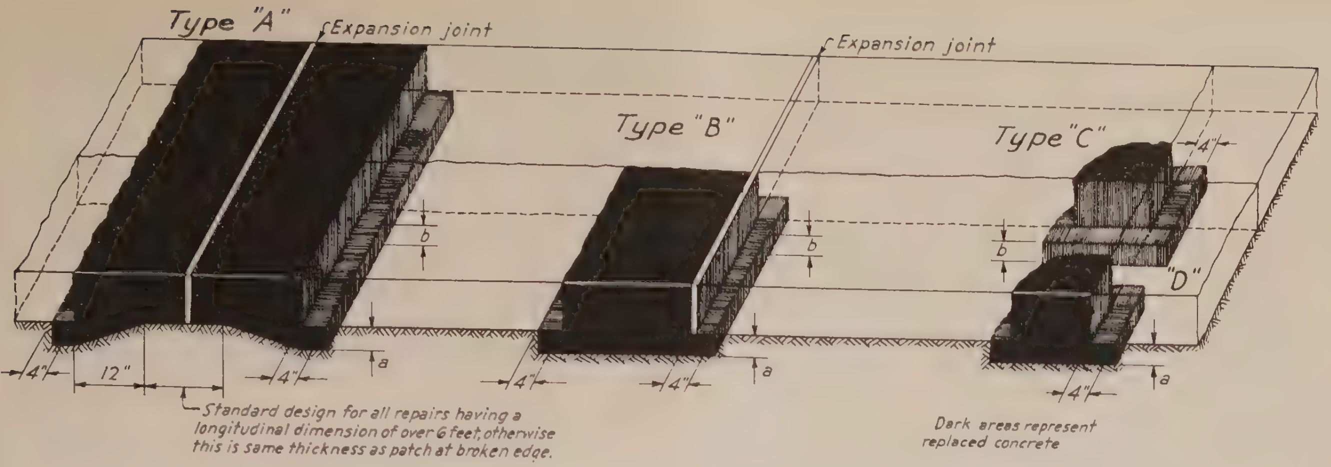
Type of Pavement	*Miles*
Concrete	4,275
Brick	142
Bituminous	1,838
Oil Processed	1,470
Surface treated, Stone, Gravel, Sand-clay, etc.	1,092
Untreated Stone, Gravel, Sand-clay, etc.	2,386
Topsoil	133
Graded	59
Total	11,395

Elmhurst Test Road Described in Booklet

THE test road of cement-bound macadam, built by the Portland Cement Association at Elmhurst, Ill., and described in an illustrated article on page 9 of the July (1933) issue of CONCRETE, is the subject of a new bulletin issued by the Association, under the title "The Elmhurst Test Road—and What It Taught Us About Cement-Bound Macadam."

The booklet is essentially a technical summary of the test results and the conclusions to be drawn. Tables show various gradings of fine and coarse aggregate and different proportions of grout used, together with compaction factors and compressive strengths obtained.

Highway engineers can obtain copies of this valuable booklet by writing to the Portland Cement Association. No charge will be made for single copies.


Type "A"
℄ Expansion joint
℄ Expansion joint
Type "B"
Type "C"
4"
b
b
b
"D"
a
a
a
4"
12"
4"
4"
4"
4"
Standard design for all repairs having a longitudinal dimension of over 6 feet, otherwise this is same thickness as patch at broken edge.
Dark areas represent replaced concrete

Drawing illustrates directions for repairing concrete pavements

Recommend Standard Repair Practice for Concrete Pavements

UNDER the heading of "Recommendations for Repairing Concrete Pavements," the Portland Cement Association has issued an illustrated folder containing valuable instructions in specification form, covering this important phase of highway maintenance.

For the information and convenience of readers engaged in the field of highway engineering, the instructions are here presented in full.

APPLYING TO ALL CROSS-SECTIONS

All Repairs

No patch shall contain an angle of less than 45 deg. No piece of concrete having an unbroken area of less than 10 sq. ft. shall be left in place.

Repair of breakage due to very poor subgrade conditions shall be preceded with adequate subgrade preparation such as providing drainage, installing sub-base, etc.

The outside patch thickness is equal to the thickness of the old slab plus an additional thickness "a" for thin-edged pavements or "b" for uniform or thickened-edge pavements.

In breaking out broken areas, preparatory for patching, the concrete will be broken away from any steel embedded in the old pavement, and this steel replaced in the patch in approximately the same position it occupied in the old slab.

All unruptured faces of transverse joints occurring at repairs shall be carefully inspected to determine if they are perpendicular to the pavement surface and, if necessary, cut vertical.

All edges of the old pavement shall be underpinned for a width of 4 in.

The underside of the old pavement, at the underpinning, shall be cleaned of all loose, compressible material.

Joints

All transverse expansion or contraction joints occurring at patches shall be reproduced in the patch.

All patches for full pavement width in pavements of two or more lanes shall contain longitudinal joints.

All breakage for full pavement width due to expansion shall contain a transverse expansion joint, as illustrated by Type "A."

In the event that repairs of Type "B," "C" or "D" occur at transverse expansion joints, the old expansion joint will be replaced with a new expansion joint of the same width as the old joint for the depth of the old pavement. It shall be installed perpendicular to the pavement surface and center line.

Full Pavement Width Repairs, Type "A"

All breakage for full pavement width having a longitudinal length of less than 6 ft. shall be repaired by a patch of uniform thickness, as illustrated by the outside thickness of Type "B."

All breakage for full pavement width having a longitudinal length of more than 6 ft. and less than 40 ft. shall be repaired as illustrated in Type "A." The design of that part of the repair more than one foot from the underpinning shall be comparable to the standard design for the road, including at least one transverse expansion or contraction joint.

All breakage for full pavement width having a longitudinal length of more than 40 ft. shall be repaired as illustrated in Type "A." The design of that part of the repair more than one foot from the underpinning shall be comparable to the standard design for the road, including at least one transverse expansion or contraction joint at each end of the patch within 10 ft. of the underpinning.

Corner Breaks, Type "C" or "D"

All repairs of breakage progressing from breaks of Type "C" or "D" shall be obtained by extending the patch transversely as needed.

Where a longitudinal joint or crack is present, all internal or external corner breaks (such as Type "C" or "D"), or progressive breakage from such corners, extending transversely beyond the quarter point in the pavement, shall be broken out to the center or outside edge and repaired in the manner illustrated by Type "B."

THICKNESS OF PATCHES

Thin-Edge and Uniform-Thickness Pavements

Type "A," Full Width Repair. The patch shall have a total uniform thickness at the broken edge of the old pavement equal to the outside edge thickness of the old slab plus 4 in., to give a depth of underpinning at the outside edge, "a," of 4 in.

As previously noted for repairs having a longitudinal dimension of more than 6 ft., the depth of patch one foot away from the underpinning shall be the same as the standard designs for the road.

Type "B," Half Width Repair. The patch shall have a total uniform thickness equal to the outside edge thickness of the old slab plus 4 in.

Type "C," Internal Corner Repairs and Type "D," External Corner Repairs. The patch shall have a uniform thickness equal to the thickness of the outside edge of the old pavement plus 4 in.

Thickened-Edge Pavements

Type "A," Full Width Repair. The patch shall have a total uniform thickness at the broken edge of the old pavement equal to the center thickness of the old slab plus 4 in., to give a depth of underpinning at the center, "b," of 4 in.

As previously noted for repairs having a longitudinal dimension of more than 6 ft., the depth of patch one foot away from the underpinning shall be the same as the standard designs for the road.

Type "B," Half Width Repair. The patch shall have a total uniform thickness equal to the center thickness plus 4 in.

Type "C," Internal Corner Repairs and Type "D," External Corner Repairs. The patch shall have a uniform thickness equal to the thickness of the center of the old pavement plus 4 in.

Fleet of trucks delivering concrete burial vaults from the Des Plaines, Ill., branch of the Wilbert W. Haase Company. This plant reaches a part of the Chicago metropolitan area

Nation-Wide Merchandising Program to Reach Concrete Burial Vault Market

Haase Company Adds Low-Priced Vault to Its Line—Exclusive Territorial Licenses Granted to Individual Manufacturers —Advertising Campaign Included in Plan

A MERCHANDISING plan designed to aid local licensees, and at the same time bring the name of the company's products before the trade on a nation-wide scale, has been inaugurated by the Wilbert W. Haase Company, Forest Park, Ill., in behalf of their concrete burial vaults.

These vaults include this company's well-known "Wilbert" asphalt-lined concrete vault, as well as the recently announced vault designed for the low-priced market and sold under the name of "American Monarch."

Practical Aid to Manufacturers

The company has already granted exclusive manufacturing and territorial rights to several manufacturers, and has now begun a national program of expansion. Individual licensees will be aided in every possible manner—for example, in the services of a vault manufacturing specialist to instruct men in the technique of manufacture.

Special molds and molds for odd sizes are supplied to the manufacturer on a rental basis, thereby avoiding the necessity of locking up capital investment in equipment that is little used. Regularly-used equipment supplied in the establishment of a new plant includes molds for 95 per cent of all orders, plus special decorating and handling devices.

Reaching High-Priced and Low-Priced Markets

The two types of vault are not in competition with each other. The "Wilbert," long in the field, has been sold at a comparatively high price, on the basis of quality alone. The new "American Monarch" is a straight-sided vault designed to require the least possible width of grave. For example, a 28-in. vault will occupy a grave space only 31 in. wide, or 3 in. wider than the vault. This feature makes it possible to meet the regulations of many old cemeteries in which the allowable grave space is extremely limited.

The new vault, as previously stated, is intended to reach the low-priced and moderate-priced markets. This fact, coupled with its moderate space requirements, is expected to widen greatly the scope of the market.

Design of New Vault

The cover of the new vault is arched, to provide the greatest possible strength against the superimposed earth.

'INCOR' Makes Better Concrete

by Curing Thoroughly in Limited Time Available on Average Job

Service Strength
IN 24 HOURS
Watertight
IN 48 HOURS

CURING, that is, keeping concrete wet, cannot go on indefinitely; it costs money, interferes with use of the structure. The best concrete is that which cures thoroughly in the short time it is kept wet.

'Incor' 24-Hour Cement 'cures' or combines with water 5 times as fast as ordinary, single-burned cement. That is why 'Incor' is service strong in 24 hours—watertight in 48 hours.

By curing thoroughly in the limited time available on the average job, 'Incor'* makes concrete that is stronger, denser, more watertight.

*Reg. U. S. Pat. Off.

1 Swimming pools require dense, watertight concrete. Engineers specified 'Incor' without admixtures for this Stamford, Conn., Yacht Club pool. Job was watertight, ready to use, 24 hours after last concrete was poured.

2 Built in mid-winter with 'Incor' cement, these settling tanks for Cretona Print & Dye Works, Clifton, N. J., are giving thoroughly watertight service. Concrete heated to 60° produced 24-hour strengths equal to 7 days with ordinary cement.

3 Mill Rock Reservoir, New Haven, Conn., Water Co.; constructed of 'Incor' concrete, without surface treatment or waterproofing compound. Completed in summer, 1931, it hasn't leaked a thimbleful.

4 (*Right*) Wabash Avenue Bridge, Chicago; 'Incor' was used in precast slabs for sidewalk and roadway. Dense, watertight concrete has successfully prevented moisture absorption, assuring continuous balance between bascule leaves and counterweight.

'INCOR' 24-Hour Cement

The constant outward pressure from the cover, applied at the upper edges of the vault walls, aids the walls in resisting the side pressure of the soil and ground water. The cover has a patented tongue-and-groove seal, with the groove in the cover. During the manufacturing process this groove is sealed with a specially treated asphalt. When the cover is lowered and contacts the projecting tongue at the top edge of the vault walls, this asphalt forms a perfect waterproof seal. All asphalt used is given this special treatment, enabling it to form a seal at any temperature. It retains its consistency in the warmest weather.

Molds Quickly Stripped and Reassembled

The molds in which the new "Monarch" vaults are made are the result of many years of research and experimentation, culminating in the development of a long-lasting unit which may be stripped and set up again for re-use in a short period of time. Records at the plant of the American Vault Works, Chicago licensee of the Wilbert W. Haase Company, show that with average workmen the entire operation of stripping and setting up again is easily performed in 10 minutes. In special attempts to set records, this operation has been completed in four minutes. The American Vault Works produces more than 12,000 vaults per year, a fact which makes it imperative that their equipment can be stripped and reassembled quickly.

The Wilbert W. Haase Company has recently built extensive additions and alterations to its plant, as a direct result of the company's constantly increasing business.

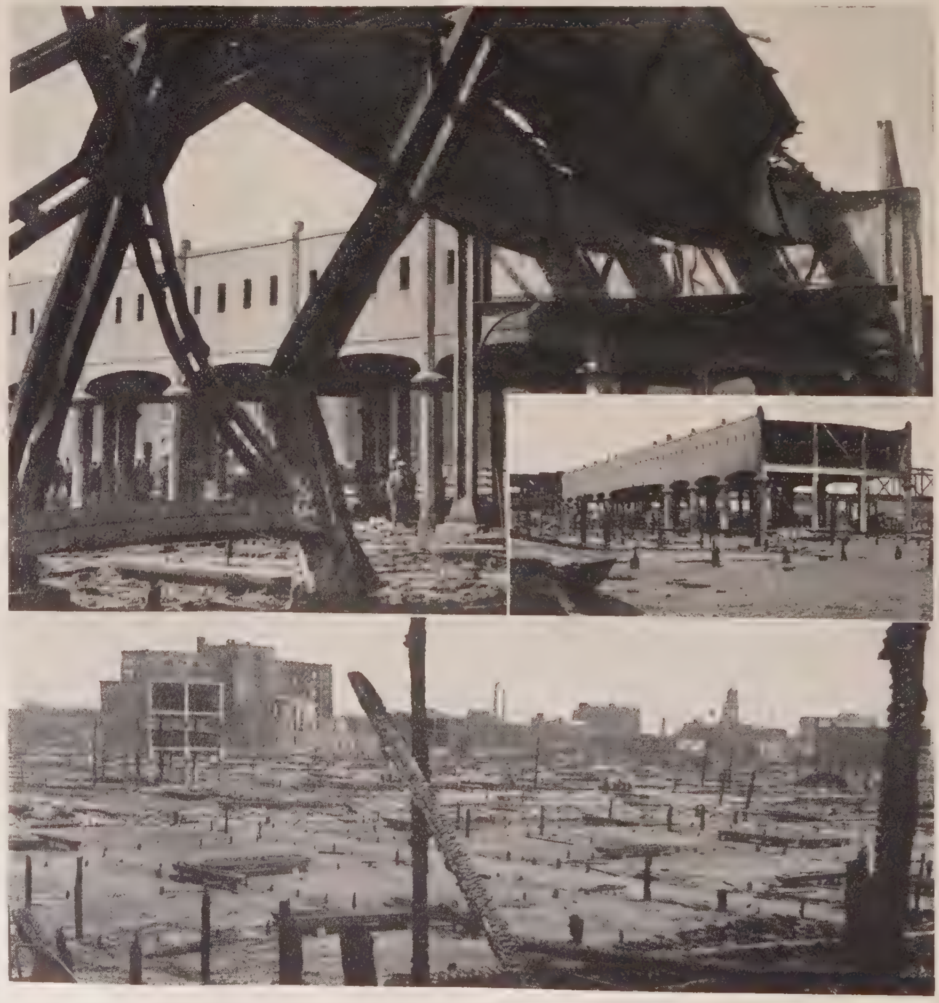
Concrete Again Proved Fireproof in Stockyards Fire

IF any further test was needed to demonstrate the value of reinforced concrete as a fireproof construction material, that demonstration was provided on a vast scale, before thousands of onlookers, by the $8,000,000 fire in the Union Stock Yards at Chicago on the afternoon of May 19.

Building after building of combustible construction was completely destroyed, as were cattle pens and overhead runways of wooden construction. The buildings destroyed included the International pavilion (not of concrete), a number of small wood frame buildings, and some brick buildings of wooden interior construction. A long stretch of the stockyards branch of the elevated railway, all of exposed steel construction, was twisted completely out of shape by the intense heat of the conflagration.

Buildings and runways of reinforced concrete construction, on the other hand, suffered no structural damage of any consequence, though the combustible contents of many of them were burned out. Notable among these were two reinforced concrete hay warehouses, in which the hay was completely consumed, creating an intense heat but causing no damage to the concrete construction.

The illustrations tell the story in a most convincing way. The upper illustration shows an undamaged reinforced concrete runway as viewed through the crumpled steel elevated railway structure previously mentioned. Wooden pens beneath the concrete runway were completely destroyed. The lower picture shows a general view of the fire-swept area (one square mile in extent) with the unburned concrete hay warehouse and frame of the Live Stock Exchange Building in the left background. The inset shows where the reinforced concrete runways ended and the wooden runways (completely consumed) began.



Concrete structures alone remained standing in the path of Chicago's stockyards fire

SERVICISED
EXPANSION JOINTS

SPONGE RUBBER
CORK
FELT SIDED
PLAIN
COMPOSITION

●

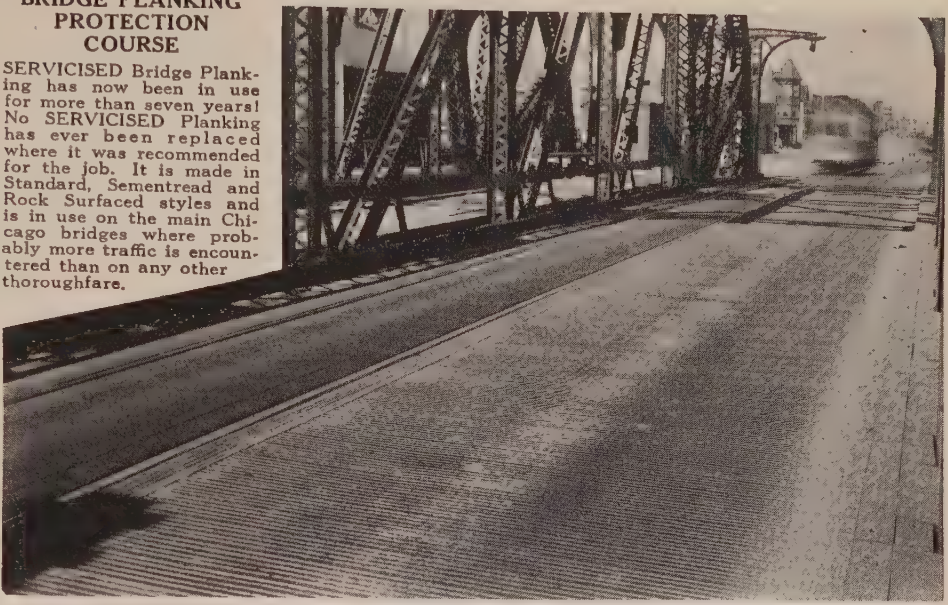
SERVICISED
Expansion Joints

SERVICISED Expansion Joints, whether sponge rubber cork, felt sided, or plain composition, excel! SERVICISED Expansion Joints have given service over a period of twelve years, and are found in State highway work in every State in the Union which has used Expanion Joint within this period. You will not be doing justice to your organization without securing prices and learning about these products.

●

BRIDGE PLANKING PROTECTION COURSE

SERVICISED Bridge Planking has now been in use for more than seven years! No SERVICISED Planking has ever been replaced where it was recommended for the job. It is made in Standard, Sementread and Rock Surfaced styles and is in use on the main Chicago bridges where probably more traffic is encountered than on any other thoroughfare.

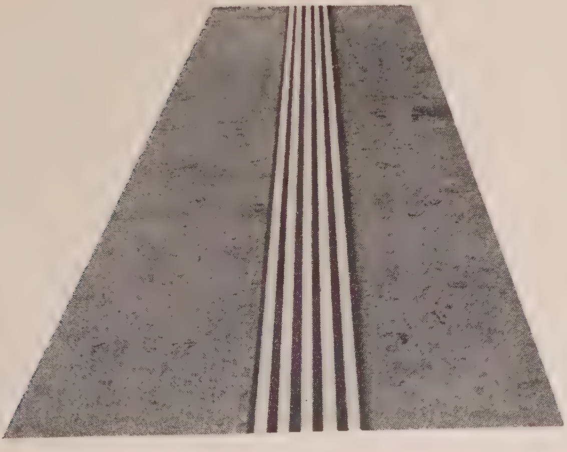


Western Avenue Bridge, Chicago, Illinois

ASPHALT PLANKING
STANDARD—SEMENTREAD—ROCK SURFACED

SEMENTREAD is a new skid-proof planking—one which can be **guaranteed skid-proof**—when laid horizontal to the traffic it promptly stops the forward motion of the car, and when laid vertical to the traffic it stops the side skid as well as forward skidding. SEMENTREAD comprises a cement rib keyed in the asphalt plank surface, which adds rigidly to the surface also making it skid-proof. This material is especially adapted on city bridges and viaducts where wet days are a menace to traffic and where short skids are dangerous and cause accidents.

Be sure to learn about this product before laying another foot of planking!



Skid-Proof Your Bridges

CENTER ROAD MARKINGS

SEMENTREAD planking in six or eight inch widths is highly adapted for road marking purposes having alternate black and white or black and yellow lines—the lines consisting of Portland cement.

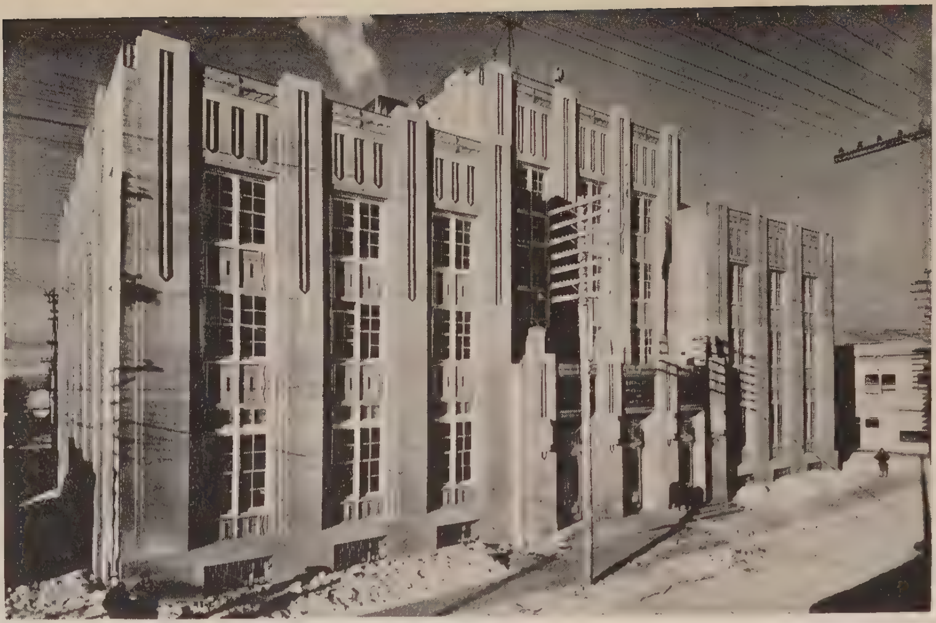
ROCK SURFACED PLANKING

ROCK SURFACED planking comprises SERVICISED asphalt planking having imbedded in its surface particles of rock. We do not believe that this is in any measure as skid-proof as SEMENTREAD. It, however, prevents skidding to a greater extent than the plain surfaced asphalt planking.

Write today for full particulars on SERVICISED Products

SERVICISED PRODUCTS CORPORATION
6051 WEST 65th STREET, CHICAGO

Federal Building of Architectural Concrete



New Federal Building at Fairbanks, Alaska, is of monolithic concrete

THE new Federal Building at Fairbanks, Alaska, up near the Arctic Circle, is a notable example of the successful use of monolithic concrete for exterior architectural treatment.

In the design of this building the architect proportioned the larger masses of the structure with due regard for the material to be employed, and in a manner well adapted to the requirements of concrete. The ornamental details, likewise, are of such a nature that they can be executed successfully in concrete.

Much credit for the excellence of the exterior finish of this building is due the general contractor, the Walter MacDonald Construction Co., of St. Louis, Mo. This same contractor has also built a monolithic concrete school building in Fairbanks, designed in an appropriate style of architecture.

See Good Prospects Ahead for Construction Industry

Survey by Brookmire Organization Has Encouraging Features

THE Brookmire reports for July have an encouraging word or two. The following paragraphs are quoted from these reports:

July 2—The sluggishness with which the building industry is recovering suggests the urgent need for accelerating the revival of durable goods industries if the general recovery is to be maintained, particularly since the immediate possibilities in textile industries appear to have been exhausted. A second basic factor in the outlook for business during the remainder of this year and into 1935 is the budgetary inflation to which the Government is committed. This liberal spending by the Government is looked upon as a stop-gap until the influences characteristic of recoveries in the past have acquired enough momentum to take the burden of employing idle workmen off the Government's hands. Depreciation and obsolescence will ultimately lead to replacement or modernization of the equipment already in existence: homes, factories, railroads, farms, stores, automobiles, machinery, furnishings, etc.

July 16—Aside from the farm situation, the dominating influences in the business outlook are the Government spending and the possibility that the Administrator of the Housing Act will proceed with sufficient promptness to result in a beginning in the home renovation and construction drive.

July 16—In view of the high level of production costs, we do not believe that the decline in prices (steel) will go materially further, particularly since the trend of consumption in the long run is upward.

July 23—Retail yard stocks (lumber) are, in many instances, so low that should the home building program develop a sizable demand this fall they would be in no position to handle it, yet these yards are making no efforts to maintain reasonable stocks. We believe that since prices are now subject to administrative change that lumber buying could be appreciably aided by a statement of the length of time at which specified levels would prevail.

Building activity is likely to hold up fairly well in the late season, and a considerable amount of renovation work will probably be begun. Substantial reduction in costs would pave the way for an active season next spring, and it is to be hoped that union labor leaders will recognize the wisdom of co-operating with the government in reviving building. Buyers of building materials should make liberal purchases when price reductions are made.

New Jersey Kills Diversion

THE New Jersey Highway Users Conference has won a definite victory with the defeat of a legislative measure that proposed to divert $10,000,000 of authorized highway bonds into the channels of poor-relief. A substitute measure was passed providing an equal appropriation from inheritance tax revenues.

BOOKS On Concrete

List No. 1—Reinforced Concrete Engineering Design

(Prices quoted are for cash in advance, and include postage)

GENERAL ENGINEERING HANDBOOK. By Charles Edward O'Rourke and 29 associates. Flexible cover; 921 pages, 5 by 8 in., numerous tables, diagrams, and illustrations. Price **$4.00**

This book assembles a great amount of fundamental engineering data in usable form, 31 separate sections dealing with as many specific branches of engineering. Of particular interest to engineers who specialize in the use of concrete as a structural material are sections devoted to "Highways," by Thomas R. Agg; "Reinforced Concrete Structures," and "Stresses in Framed Structures," by Charles Edward O'Rourke; "Engineering Materials," by Herbert H. Scofield; "Foundations," by Roland P. Davis; and "Mechanics," by Alfred P. Poorman.

REINFORCED CONCRETE CONSTRUCTION. By George A. Hool, Professor of Structural Engineering, University of Wisconsin.

Vol. I—Fundamental Principles. Third Edition. 380 pages, 6x9, 139 illustrations, 18 tables, 28 diagrams **$3.50**

Vol. II—Retaining Walls and Buildings. Second Edition. 700 pages, 6x9, illustrated..........**$6.00**

Vol. III—Bridges and Culverts, 688 pages, 6x9, over 600 illustrations, 41 plates..........**$6.00**

CONCRETE ENGINEERS MANUAL. By Samuel Baker and A. DeGroot. Cloth, 401 pages, 5 by 7¼ in., numerous drawings, charts and tables. Price **$3.00**

This volume is intended as a textbook for students of concrete engineering, and as a reference book for designers, foremen, inspectors, and others involved in the design of concrete structures and in the making and placing of concrete. The book contains a complete description of the modern methods of proportioning concrete mixtures, mixing and placing concrete and steel, and providing waterproofing. Mathematical tables and the fundamental principles of mathematics and mechanics of materials, as applied to reinforced concrete designs, are included.

Among other subjects treated in individual chapters are form work, foundations, design of retaining walls, and estimating concrete work.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin, and E. R. Maurer, Professor of Mechanics, University of Wisconsin. Fourth Edition. Revised and largely rewritten. 461 pages, 6 by 9. Fully illustrated. Cloth Net **$4.00**

A general textbook on design, including material from actual designs relating to experimental results, and the theory of flat slabs.

CONCRETE ENGINEERS' HANDBOOK. By George A. Hool and Nathan C. Johnson, assisted by S. C. Hollister, and with chapters by Harvey Whipple, Adelbert P. Mills, Walter S. Edge, A. G. Hillberg and Leslie H. Allen. 800 pages, 6 x 9. Illus. Flexible binding. Price **$6.00**

A compact reference book, containing tables, formulae and data on plain reinforced concrete, covering the entire field.

HANDBOOK OF REINFORCED CONCRETE BUILDING DESIGN. By A. R. Lord, Consulting Engineer. 261 pages, 5¼ x 7½, 156 tables and diagrams. Flexible leather. Price **$1.00**

A compact yet comprehensive handbook for the designer of reinforced concrete buildings. The author has presented numerous tables and diagrams developed as time savers during his extensive experience in the design and construction of buildings. Use of diagrams is illustrated with solutions of typical design problems.

CONCRETE PLAIN AND REINFORCED. By the late Frederick W. Taylor, Sanford E. Thompson, and Edward Smulski. Vol. I. Theory and design of Concrete and Reinforced Structures. 969 pages, 6 x 9, 311 figures, 42 tables, 25 diagrams. Vol. II. Theory and Design of Continuous Beams, Frames, Building Frames and Arches, 688 pages, 6x9, 224 figures, 5 tables, 31 diagrams. Cloth. Vol. I, **$8.00**; Vol. II, **$7.50.**

For more than twenty years "Concrete, Plain and Reinforced" has been the recognized standard in its field. Volumes I and II are far more complete than the earlier editions that appeared in single volumes.

REINFORCED CONCRETE AND MASONRY STRUCTURES. By Hool and Kinne. 722 pages, 6 x 9, illustrated. Price **$6.00**

The work of 14 specialists. This book offers a practical and detailed discussion of every important element entering into the design and construction of concrete and masonry structures. Particularly noteworthy are the very thorough treatments of Reinforced Concrete Buildings, Concrete Forms, Chimneys and Concrete Detailing.

REINFORCED CONCRETE DESIGN SIMPLIFIED. By James R. Griffith, Professor of Structural Engineering, Oregon State Agricultural College. This is the fourth printing of a series of 38 full-page simplified design charts based on the design regulations approved by the Joint Committee on Concrete and Reinforced Concrete, and by the American Concrete Institute. As a designers' aid these charts are indispensable. Price **$1.00** This book is only sold in conjunction with yearly subscription—see Special Combination Offer.

ELEMENTARY GUIDE TO REINFORCED CONCRETE. By Albert Lakeman. Seventh edition, revised 1930; 94 pages, 79 illustrations. Price **$1.25**

This book is written for the builder, the student, the foreman, or anyone not having a previous knowledge of the principles of reinforced concrete design. Individual chapters cover loads and reactions, reinforcement, neutral axis, reinforced concrete beams, bending moments, shearing stress, reinforced concrete columns and walls, concrete bases, and concrete foundations.

REINFORCED CONCRETE DESIGNERS HANDBOOK. By Chas. E. Reynolds. Published in 1932; 300 pages, 40 designing tables, 51 illustrations. Price **$5.00**

This book contains complete data for the design of all classes of reinforced concrete structures, written by an engineer who is familiar with the designing practice of the leading British specialists in reinforced concrete.

REINFORCED CONCRETE WATER TOWERS, BUNKERS, SILOS AND GANTRIES. By W. S. Gray. Published in 1933; 256 pages, 170 illustrations, 2 folders. Price **$4.00**

Written by an author with practical experience, this book supplies the designer much needed information on the design of structures of these unusual types. The book includes many labor-saving diagrams. Other subjects include heat transmission through concrete walls and calculation of stresses due to hot liquids. A large part of the book is devoted to construction methods and cost estimating.

REINFORCED CONCRETE RESERVOIRS AND TANKS. By W. S. Gray. Published in 1931; 200 pages, 119 illustrations. Price **$4.00**

This book deals in a thoroughly practical manner with the design and construction of plain and reinforced concrete reservoirs and tanks and other water-containing structures both above and below ground level, and both covered and open types. Joints in floors and walls are given special attention.

SPECIAL COMBINATION OFFER: $1.50 (or $2.00 for Cement Mill Edition) added to the price of any of the above listed books will entitle you to one years subscription to Concrete or extend your present subscription one year from its present expiration date. Foreign and Canadian subscribers please write for details.

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Patents on Concrete Walls

I am looking for a book that describes the various patents issued on monolithic concrete wall construction for dwelling houses. Can you refer me to anything of this kind?—M. C. S., Bartow, Fla.

A recent book on concrete houses is known as "Concrete Cottages, Bungalows and Garages," by Albert Lakeman. It contains 130 pages and 86 illustrations. This book may be obtained at $2.50 through the book department of CONCRETE. Booklets on monolithic wall construction may also be obtained from the Portland Cement Association.

You are referred also to the Wedberg system of concrete house construction. You can obtain further information by addressing A. W. Wedberg, care of Klekamp & Whitmore, Architects, 140 South Dearborn Street, Chicago. This system was described in an illustrated article in the April, 1934, issue of CONCRETE, pages 9 and 10.

In regard to patents, some 12 or 14 years ago the Portland Cement Association published a list of more than 60 patented systems of concrete wall construction, most of which are now "dead letters," and some have expired. A list brought down to date would, therefore, contain many "systems" that are no longer being promoted. You can, however, obtain a list of the numbers of the various patents issued on this subject, by writing to the U. S. Patent Office, Washington, D. C. Copies of patent papers may be obtained at 10 cents each.

Concrete Walls Without Forms

I contemplate building a home in the mountains, and wishing to avoid high insurance rates I would like to build it of concrete. Have you published anything recently on practical methods of building reinforced concrete walls without forms? The site is in a somewhat inaccessible location where the construction of form work would involve considerable additional trouble and expense.

Has any recent book been published on this subject?—E. A., San Leandro, Calif.

Two systems of concrete wall construction of this type have been described and illustrated in comparatively recent issues of CONCRETE. One of these illustrated articles will be found on pages 14 and 15 of the issue of June, 1933, while the other appears on pages 7 and 8 of the issue of November, 1933.

In each case the method of construction involves the use of specially molded concrete units providing grooves into which steel reinforcement may be placed. This provides horizontal steel reinforcement in each joint between courses. Provision is also made for placing vertical steel rods, in order that the reinforcement of the wall may be complete. In one of the systems of construction described, after each row of units was placed dry, 3/8-in. steel rods were placed longitudinally in the grooves or channels formed by the upper surface of the precast units. The rods were lapped at the ends so as to form continuous horizontal reinforcement all around the building, at vertical intervals of 12 inches. After three or four rows of the wall units were set, 3/8-in. steel rods were set into the vertical circular spaces between units. This 3-ft. or 4-ft. height of wall was then concreted by filling all the horizontal and vertical grooves or cylindrical spaces formed by the concave grooves of the individual units. The individual blocks in this particular case are cast with two rows of hollow spaces, so that, if desired, only the outer row of spaces may be filled with concrete, the interior row remaining hollow to serve as insulation. Or, better still, the interior row of hollow spaces may be filled with some insulating material such as dry sawdust.

An interesting book on this subject has been published under the title of "Concrete Cottages, Bungalows and Garages," by Albert Lakeman. Copies may be obtained through the book department of CONCRETE at $2.50 each.

You can also obtain excellent pamphlets on the subject of monolithic concrete house construction by writing to the Portland Cement Association, 33 W. Grand Avenue, Chicago, Illinois.

Cost Accounting for Products Plants

I am in the concrete products business, and am looking for a book covering the proper distribution of overhead charges against the various products we make. The purpose is, of course, to arrive at the proper cost of each of our products.—E. C. P., Seattle, Wash.

The Book Department of CONCRETE, 400 W. Madison St., Chicago, carries a book on this very subject, giving a system that is simple and easily applied. The book, written by A. E. Wynn, is entitled "Making Precast Concrete for Profit; a System of Cost-Keeping and Determining Profits."

You are referred also to a series of articles on "Profitable Manufacture of Concrete Building Units," by Fred A. Sager, printed in CONCRETE in the issues from January to December, 1931. Costs, overhead charges and accounting are given special attention in the issues of May, October, November and December, 1931.

Monolithic Concrete House Forms

Where can I get information on the Wedberg system of forms for the construction of monolithic concrete houses, described in your April (1934) issue, pages 9 and 10?—M. J. S., Los Angeles, Calif.

Information on this system can be obtained by addressing either Bernard R. Klekamp or Axel W. Wedberg, in care of Klekamp & Whitmore, Architects, 140 So. Dearborn St., Chicago.

From the Patent Office

By J. KAPLAN
Patent Attorney, Washington, D. C.

Expansion joint and installation method: George P. Edmonds, Wilmington, Del. U. S. Pat. 1,960,374.—The method of constructing sectional paving and like structures comprising: laying sections of such size and form as can, within the extremes of temperature to which the structure will be subject, freely expand and contract without the development of destructive internal stresses, spacing said sections so that the width of the gap between the sections under maximum expansion will not be materially less than one-third the width of the gap defined by the sections under maximum contraction, forming, of cork, or equivalent highly resilient material, a filler strip having a normal thickness greater than the width of the gap defined by the sections under maximum contraction, compressing said strip to such an extent and maintaining said compression for such a period as to effect temporary, self-maintained deformation therein characterized by a reduction in the thickness thereof to less than the normal width of the gap defined by said sections, placing said strip in said gap while still in its temporary, self-maintained, deformed state, and allowing said strip to expand and fill said gap.

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Building construction method: Neal Garrett, Glendale, Calif. U. S. Pat. 1,963,984.—The method of constructing a building includes erecting a plurality of form units to provide a form face extending into an area to be occupied by a wall and perpendicular to the wall; forming a reinforced cementitious slab on said face up to and exteriorly of said area and providing reinforcing projecting from said slab and extending into said area; removing the units of the form work that extend into said area; bending the projecting portions of the slab reinforcing to provide portions thereof extending perpendicularly with respect to said slab; then erecting the wall of cementitious material and embedding therein the projecting portions of the slab reinforcing, and removing the units.

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Concrete pipe construction: Bozidar J. Ukropina, Los Angeles, Calif. U. S. Pat. 1,958,872.—The pipe includes a reinforcing cage embedded therein, the cage including a band at each end of the pipe with the outer surface exposed, a plurality of spaced rings secured to the inner surface of each of the bands, a plurality of circumferentially spaced longitudinally extending bars secured to the rings, a plurality of spaced tongues on the bars, the tongues being stamped from the bars and being inclined at an angle to the bars, resilient packing rings engaging the inner surfaces of the end bands and the inner surfaces of the rings.

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Insulating cement: Horace N. Clark, Bound Brook, N. J. U. S. Pat. 1,959,658.—The heat insulating cement consists of a predominant proportion of mineral wool, a substantial amount of diatomaceous earth, a binding agent, a quantity of metallic powder, capable of reacting with an alkaline hydroxide to generate hydrogen, up to about one per cent of the total mixture and a quantity of alkaline hydroxide up to about five per cent of the total mixture depending upon the strength of the alkaline hydroxide.

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Pavement and making: Carl W. Allshouse, East Cleveland, Ohio. U. S. Pat. 1,958,506.—The method of treating bituminous covered portions of pavement consists in first applying to the bituminous coating a layer of mineral material, such material having been moistened with an ignitable liquid which upon burning is capable of producing fluidity in the bitumnous coating, then igniting such moistened material and permitting the softening of the coating and the impregnation thereof by the abrasive material.

●

Method of widening concrete roads: John W. Isett, Hinsdale, Ill. U. S. Pat. 1,957,596.—The method consists of boring a plurality of horizontally spaced apart holes in the edge of the existing concrete road, securing an anchoring device in each hole with one end of the anchoring device protruding from the hole, and pouring new concrete adjacent the edge of the old concrete to the desired height and width, to cover the anchoring device.

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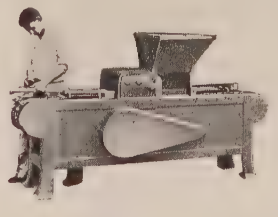

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New Books and Pamphlets

Portland Cement Manufacture

PORTLAND CEMENT. By A. C. Davis, works managing director, Associated Portland Cement Manufacturers, Ltd. Cloth, 435 pages, 6 by 9 in., 262 illustrations, 22 tables. Available through Book Department of CONCRETE, 400 W. Madison St., Chicago, at $7.50, postpaid.

This new book will be welcomed as an authority on present-day British and continental practices in the manufacture of cement. The author, who is well qualified by experience, discusses and analyzes such important problems as modern manufacturing methods and organization; formation and nature of cement raw materials throughout the world; factors governing choice of materials and manufacturing processes; raw material and clinker-grinding problems; improving the efficiency of the rotary kiln; methods of coal feed, slurry drying, and kiln control; reactions in burning cement; rotary kiln heat balances; conservation of heat in rotary kilns; advantages of the purchase of electricity compared with generation at the cement manufacturing plant; modern methods of packing and shipping cement; production costs; mineralogy and chemistry of cement.

Vibrated Concrete

VIBRATION—A BETTER METHOD OF PLACING CONCRETE is the title of a new 32-page illustrated booklet published by the Portland Cement Association, 33 W. Grand Ave., Chicago.

Quoting from the booklet: "Engineers and contractors have reported successful results with concrete placed by high-frequency vibration. It improves quality, they say. Tests by our research laboratory, and by state highway departments and leading universities have substantiated the excellent results reported from the field. Hence this booklet, to summarize the most recent data on placing concrete by high-frequency vibration."

Additions to Concrete Design Charts

ALBERT DESIGN CHARTS, by Odd Albert. Published by the Opla Company, P. O. Box 66, East Orange, N. J. Individual charts for loose-leaf binding, size 8½ by 11 in. Price $1.20 for set of 12 charts.

This new set of 12 charts, designated by the publisher as Set *B*, is the second of a series, the first of which was mentioned in this column on page 18 of the October (1933) issue of CONCRETE. Set *B* covers continuous beams and girders, beams with top and bottom reinforcement, members under combined bending and compression, and number and spacing of stirrups.

Architectural Details for Cast Stone

CAST STONE is the title under which the Cast Stone Institute is distributing 8½ by 11-in. data sheets containing architectural details, specifications and technical data.

These sheets, in the nature of service bulletins, are issued to show how cast stone may be utilized to the best advantage in its own character. The bulletins will supply architects with reliable and impartial information on the nature, uses and proper treatment of cast stone. Copies may be obtained on request, by addressing C. G. Walker, assistant secretary, Cast Stone Institute, 33 W. Grand Ave., Chicago.

ORGANIZATIONS

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C.

American Chemical Society, Mills Building, Washington, D. C.

American Concrete Institute; Harvey Whipple, Secretary, 7400 Second Blvd., Detroit, Mich.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Institute of Chemical Engineers, Bellevue Court Bldg., Philadelphia, Pa.

American Railway Engineering Association; E. H. Fritch, Secretary, 59 East Van Buren St., Chicago, Ill.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-Ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 260 S. Broad St., Philadelphia, Pa.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Wm. F. Hurd, Secretary, Room 203, City Hall, Indianapolis, Ind.

Cast Stone Institute; C. G. Walker, Asst. Secy., 33 West Grand Ave., Chicago, Ill.

Cement Institute; H. C. Lundborg, General Manager, 11 East 44th St., New York City.

Concrete Reinforcing Steel Institute; R. W. Johnson, Secretary, 333 North Michigan Ave., Chicago, Ill.

Engineering Institute of Canada; 2050 Mansfield St., Montreal, Quebec.

Highway Research Board; Roy W. Crum, Director, 2101 Constitution Ave., Washington, D. C.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

National Concrete Masonry Association; Horace W. Bush, Secretary and Treasurer, 211 Edgemont Place, Teaneck, N. J.

National Crushed Stone Association; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C.

National Fire Protection Association; Franklin H. Wentworth, Managing Director, 60 Batterymarch St., Boston, Mass.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Bldg., Washington, D. C.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, Earle Building, Washington, D. C.

National Terrazzo and Mosaic Association; J. M. Fuhrman, Secretary-Treasurer, 524 Brook Street, Louisville, Ky.

New Jersey State Concrete Products Association; Horace W. Bush, President, Lyndhurst, N. J.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

Wire Reinforcement Institute; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

Wisconsin Concrete Products Manufacturers' Association, Inc.; L. E. Schwalbe, Secretary, Wauwatosa, Wis.

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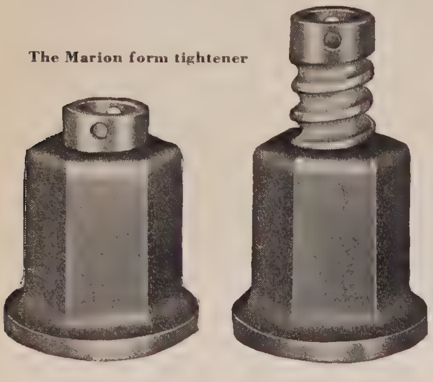
EQUIPMENT AND MATERIALS

A NEW form tightener has been introduced for use with wire ties, which eliminates the twisting of wire under tension and makes it unnecessary for workmen to reach or climb into forms to twist ties for adjustments. It is thus particularly well adapted, the makers say, for centering on thin wall sections.

The operation is simple. The two ends of the wire tie are brought through the formwork in the usual manner and passed through the tightener. A nail is inserted through a hole in the tightener screw, passing between the two ends of the tie. The wires are given a couple of turns, as at A, and then the workman, holding the nail with one hand, uses a wrench on the nut, making the wires taut and drawing the forms together to the ultimate strength of the wire, as shown at B.



The Marion form tightener

The use of this device, made by the Marion Malleable Iron Works, Marion, Indiana, is said to make accurate alignment of forms easy and economical. The tighteners, which are reclaimable, are made of certified malleable iron and are practically indestructible.

●

FLEXSEAL joint is designed particularly, the B. F. Goodrich Rubber Company of Akron says, as a substitute for nipples and flanges. The end of the hose consists of an enlargement, or bead, reinforced with numerous plies of fabric surrounding a rigid steel ring of angular cross section. The joint is assembled with the aid of split flanges and standard bolts. Two lengths of hose can thus be bolted together with the rubber ends of the hose compressed to form a seal.

●

FORD V-8 Pick-Up is now on display at all Ford dealers. The makers say it is a particularly useful truck for contractors and builders.

NEW Goodrich Multi-V belts are compounded, the B. F. Goodrich Rubber Company of Akron says, to reduce internal heat to a minimum. In this construction, preservation of balance, they say, is paramount. The three layers are balanced to resist stretch and cover wear.

●

PEASE model "11" is a new low-priced continuous blue printing equipment, washing and drying machine. This machine is being offered the users of blue-prints by the C. F. Pease Company of Chicago, Ill.

●

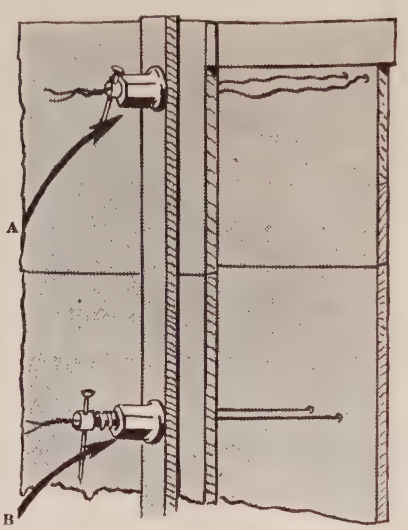


Diagram showing form tighteners in place

OXWELD type MP-4 is a new portable acetylene generator recently announced by the Linde Air Products Company, New York City. It is intended for portable service only and the makers say it is specially designed to withstand the abuse encountered in such service, particularly in overland pipe construction. With a carbide capacity of 150 lb. they say it will be of great service where large scale weldings must be carried out in the field.

●

Industrial Literature

TRUCK and Trailer Size and Weight Restrictions—1934 Edition, pocket size, of fifty-six pages, in two colors—contains the laws for each state governing the size and weight restrictions of trucks and trailers, arranged alphabetically by states. The interpretations of the laws are arranged in tabular form and have been approved by a responsible public official of each state whose signature appears below the interpretation, thus assuring an authoritative interpretation, according to the Four Wheel Drive Auto Company of Clintonville, Wisconsin, responsible for this fifth edition since August, 1933.

●

A NEW vibrating screen catalog published by Link-Belt Company, Chicago, is devoted to its line of vibrating screens for screening sand, gravel, stone, coal, coke, clay, fertilizer cement etc. Unbalanced pulley as well as positive drive types are covered including a positive drive screen for operation at a flat angle—for use in places where the headroom is limited.

●

A BETTER Portable Compressor is the title of a bulletin just issued by Ingersoll-Rand. It sets forth the advantages of the company's two-stage, air-cooled portable compressor.

Both the oil-engine- and the gasoline-engine-driven units are shown.

●

BELT Conveyor Idlers is a new bulletin recently published by the C. O. Bartlett & Snow Co., Cleveland, Ohio. It contains a complete description of the popular types, together with tables of dimensions, prices and engineering data relative to spacing, capacities, angles of incline, etc.

●

Manufacturers' News

STONHARD Company, Philadelphia, claims a recent development in their resurfacer permits resurfacing or repairing industrial floors during week-end shut down. Concrete, wood, brick, asphalt or composition floors that have become rutted, rough or broken down can now be permanently repaired or completely resurfaced and ready for use in thirty-six hours, they say. Anyone handy with a trowel can use the material with success.

Stonhard Resurfacer, they claim, provides a tough, resilient surface that is waterproof, fireproof, dustless and non-skid.

●

THE Chain Belt Company announces the re-opening of its office in Houston, Texas, under the direction of J. W. Snavely. The office will be located at 3118 Harrisburg Boulevard.

Vol. XLII
No. 8

Cement Mill Section of
Concrete

AUGUST
1934

Nature of Portland Cement Clinker

Modern Methods of Research as Applied to Its Study—Study of Clinker Formation from Standpoint of Equilibrium Diagrams

By **H. G. FISK**
Petrographer, Buffington Plant, Universal Atlas Cement Co., Buffington, Indiana

Fundamental equilibrium studies on the systems lime-silica, and lime-alumina-silica, have shown what compounds are possible in portland cement clinker. Petrographic and X-ray studies have proved the existence of these compounds in commercial cement clinkers. Synthetic studies on the pure compounds and mixtures of them have indicated their functions in portland cement.

The principles of phase equilibria as applied to the portland cement regions of the lime-silica and the lime-alumina-silica systems are briefly reviewed. The application of thermo-chemical, petrographic, and X-ray crystal analysis methods to the solution of the problem of the constitution of portland cement clinker is indicated.

SECTION I

Chemistry of Portland Cement Clinker Formation from the Standpoint of Equilibrium Diagrams [1]

IN the formation of clinker from its raw materials—limestone and clayey material or slag—new chemical compounds result, and these compounds have chemical and physical properties decidedly different from those of the original raw materials. The changes have been brought about through the agency of heat. In fact, high temperatures, around 1,450 deg. C., are necessary to complete the reactions.

Silicate chemistry† is closely allied to mineralogy, as many of the compounds formed in silicate reactions occur in nature as minerals, and others not found in nature have definite physical properties and can best be investigated and studied by the methods of determinative and synthetic mineralogy. The application of physical chemistry to the science of mineralogy and the chemical problems of geology has been very valuable, and is essential in the study of silicate chemistry.

THROUGH the courtesy of the author and the editor of the Journal of Chemical Education, this article is presented to readers of the Cement Mill Edition of "Concrete." The author treats this technological subject in language that can be understood by readers who are not familiar with the chemistry of cement.

The remaining installment will deal with petrographic and X-ray methods as applied to portland cement.

The article originally appeared in the April (1934) issue of the Journal of Chemical Education.

In addition to the well-known laws of chemistry, such as the laws of the conservation of matter and energy, and the mass law, there are two general principles of fundamental importance in silicate chemistry.

The first of these is called Ostwald's rule and states that a substance tends to pass from a less stable to a more stable condition through successive changes of decreasing instability. The second of these laws is known as the principle of Le Chatelier, which states that three factors or conditions govern a system. These factors are concentration (or composition), temperature, and pressure. Further, the principle of Le Chatelier states that if one of these factors is changed, the other factors will tend to adjust themselves so as to offset or counteract the effect of the change. In silicate chemistry the small changes in pressure ordinarily encountered have such a slight effect that for most purposes pressure may be neglected, and its effect will not be taken into account in the following discussion.

In considering silicate systems it is necessary to distinguish between phases and components. A phase is a

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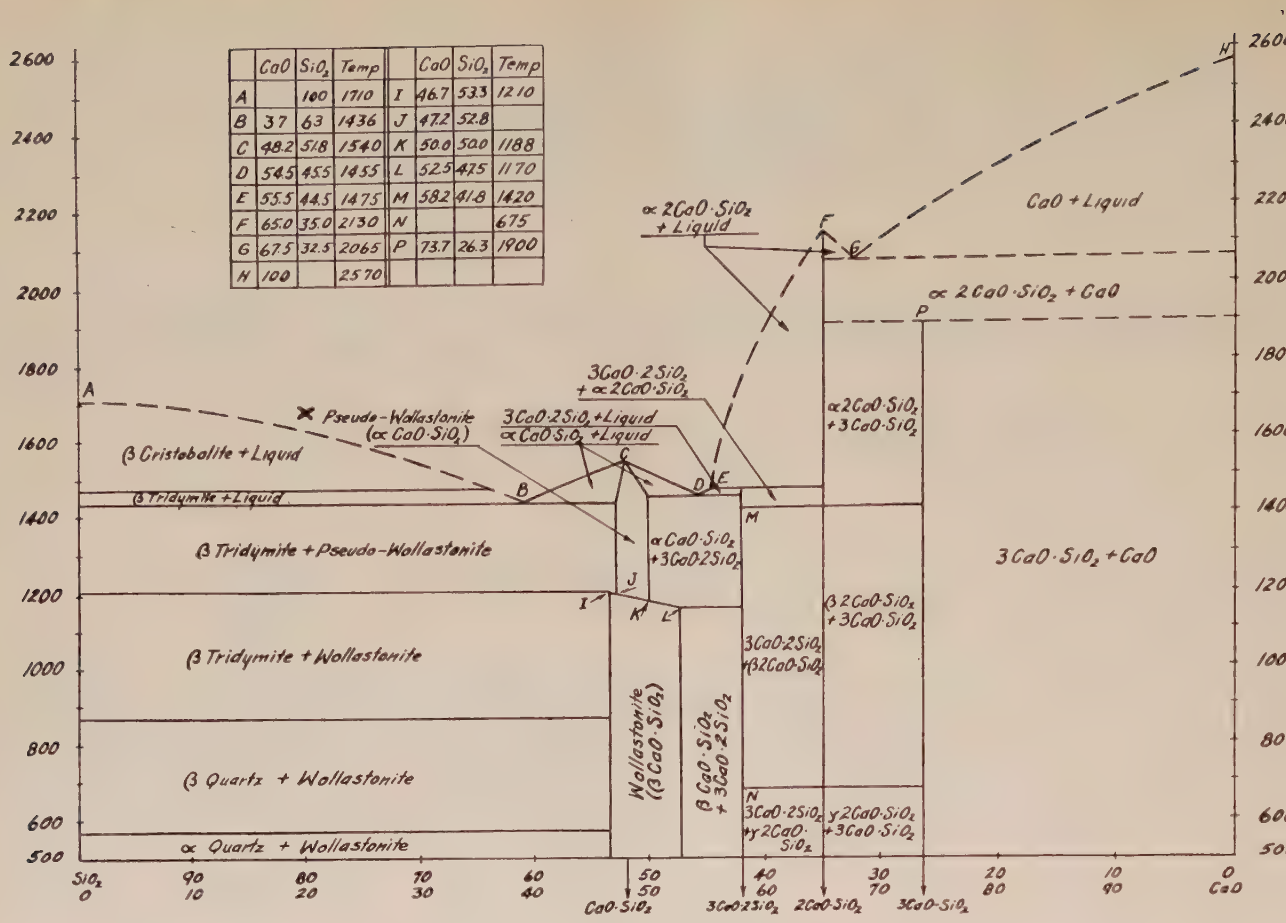
[1] There is no adequate single text in English on the application of equilibrium diagrams to silicate systems in the industry. Much of the treatment of Section I has been taken from notes obtained in two lecture courses on Thermochemical Mineralogy, given by Professor Wm. J. McCaughey at the Ohio State University.

†That branch of chemistry dealing with reactions and processes involving the compounds of silicon (and in general reactions which are carried out in the dry state—that is, those in which water solutions do not play an important part) is sometimes called "silicate chemistry."



	CaO	SiO₂	Temp		CaO	SiO₂	Temp
A		100	1710	I	46.7	53.3	1210
B	37	63	1436	J	47.2	52.8	
C	48.2	51.8	1540	K	50.0	50.0	1188
D	54.5	45.5	1455	L	52.5	47.5	1170
E	55.5	44.5	1475	M	58.2	41.8	1420
F	65.0	35.0	2130	N			675
G	67.5	32.5	2065	P	73.7	26.3	1900
H	100		2570				

$CaO - SiO_2$ SYSTEM

RANKIN AND WRIGHT AM.J.SCI. 39, 5(1915)
AS CORRECTED BY FERGUSON AND MERWIN AM.J.SCI. 48, 48(1919)
AND FERGUSON AND MERWIN AM.J.SCI. 48, 165(1919)

Figure 1. Temperature-composition diagram as developed by the Geophysical Laboratory

homogeneous, physically distinct, mechanically separable portion of a system. There may be more than one solid phase in a system, and at times more than one liquid phase (liquid immiscibility) but never more than one gas phase. The components of a system are the constituents, the concentration or amount of which can undergo independent variation in the different phases.

A One-Component System

Silica (SiO_2)[2], may be considered a one-component system. If the mineral quartz, the form in which pure silica usually occurs in nature, is heated, when a temperature of 575 deg. C. is reached a transformation from the low temperature or α form to the high temperature or β form suddenly takes place. This transformation is known as an inversion and is accompanied by a change in volume which is due to a change in state or a molecular rearrangement of the internal structure. If quartz is heated in the absence of a flux, at about 1,250 deg. C., an inversion to β-cristobalite takes place. The cristobalite is then stable on further rise in temperature until it melts to a glass at about 1,713 deg. C. If a suitable flux is present, quartz can be converted by prolonged heating between 870 deg. C. and 1,470 deg. C. to another form of silica known as tridymite. These are not the only changes which take place in the silica minerals with changes in temperature, but they illustrate the effect of that single variable, temperature, on a system of one-component. The changes in the silica minerals are very important in silica brick, which is widely employed in the steel industry.

A Two-Component System

When the effect of temperature on a two-component system is considered, the data can best be represented on a temperature-composition diagram. Such diagrams are sometimes called binary-phase, or equilibrium diagrams. Figure 1 shows such a diagram as worked out experimentally by the Geophysical Laboratory. Temperatures are indicated vertically and compositions horizontally. Each point, line, and area on the diagram means something definite. Any point chosen on the diagram represents a particular composition and a definite temperature, which is shown by reference to the temperature and composition axes. The vertical lines are known as solidus lines, and indicate conditions existing in the solid state at various temperatures. The curved lines, *A-B*, *B-C*, etc., are called liquidus lines and show the compositions of all liquids which at that temperature can be in equilibrium or coexist with solid matter in the system. The area above the liquidus lines shows the compositions and temperatures of all unsaturated liquids in the system.

Some compounds are capable of existing in more than a single crystalline form, one of which is stable over certain temperature ranges. This was shown to be the case with silica. Not all compounds melt into a liquid of their own composition when heated. Those that do are said to melt congruently. Some compounds, when a certain temperature is reached, melt incongruently; that is, decompose into a liquid of a certain composition and a solid of another composition. Such is the case with $3CaO.2SiO_2$, which at a temperature 1,475 deg. C. decomposes into a liquid of composition *E* and $2CaO.SiO_2$. This fact is shown on the diagram by tracing up the line *N-M*. Tricalcium silicate ($3CaO.SiO_2$) decomposes at 1,900 deg. C. (point *P* on the diagram) into lime and dicalcium silicate. These two compounds are then stable from 1,900 deg. C. to 2,065 deg. C. at which temperature they react together to form a liquid of composition *G*.

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[2] Sosman, R. B., "Properties of silica," Chemical Catalog Co., New York City, 1927; McDowell, J. Spotts "A study of the silica refractories" *Trans. Am. Inst. Mining Met. Engrs.*, 1917.

Compositions which are the lowest points on two liquidus lines are called eutectics and represent liquids which may be in equilibrium with two solid phases at a definite temperature. A eutectic is, therefore, the lowest melting mixture of the two solid phases with which it can be in equilibrium. Some liquids can be in equilibrium with two solid phases and yet not be the lowest point on the liquidus lines of both. These are called invariant points, not eutectics. Point *E* is such a point.

Predicting the Composition

By means of an equilibrium diagram it is possible to predict, precisely, what a system will consist of at any temperature, providing its composition may be represented on the diagram, and assuming it has been held at the temperature in question a sufficient length of time for equilibrium to have been reached. It is also possible to predict what will happen, and at what temperature, to any composition on the diagram, either on cooling or heating. For example, if a composition represented by the point *x*, consisting of 80 per cent SiO_2 and 20 per cent CaO, is maintained at a temperature of 1,680 deg. C. the diagram shows that it will be a liquid which is not saturated with either lime or silica. On cooling such a composition, it would remain entirely liquid until a point on the liquidus was reached at a temperature of about 1,650 deg. C. At this temperature, the liquid would be saturated with silica; and on cooling below this temperature, cristobalite, a form of silica, would crystallize or precipitate from the liquid. As silica was abstracted from the liquid it would change in composition along the line *A-B*, in the direction of *B*. Continued decrease in temperature would increase the amount of solid (cristobalite) at the expense of the liquid, which would be continually changing in composition until a temperature of 1,436 deg. C. was reached, at which temperature the composition of the liquid would be at *B*. Since *B* represents the eutectic in equilibrium with $CaO.SiO_2$ as well as silica, the former compound would appear in the solid phase; and both would crystallize together, with the composition of the liquid remaining at *B*, and the temperature remaining constant until all of the liquid had disappeared. Further abstraction of heat from the system would lower the temperature, and such changes as would take place would be in the solid phases, as indicated on the diagram.

In heating an intimate mixture of lime and silica, of composition *x*, changes would take place in the reverse order of those described for cooling the melt. The diagram not only shows what takes place qualitatively, but by means of a method known as the "lever reaction," which will not be discussed, it is possible to show graphically on the diagram the relative proportion of liquid to solid or solid to solid at any temperature for any composition in the system. This quantitative relationship may also be obtained algebraically.

Tricalcium Silicate Most Important

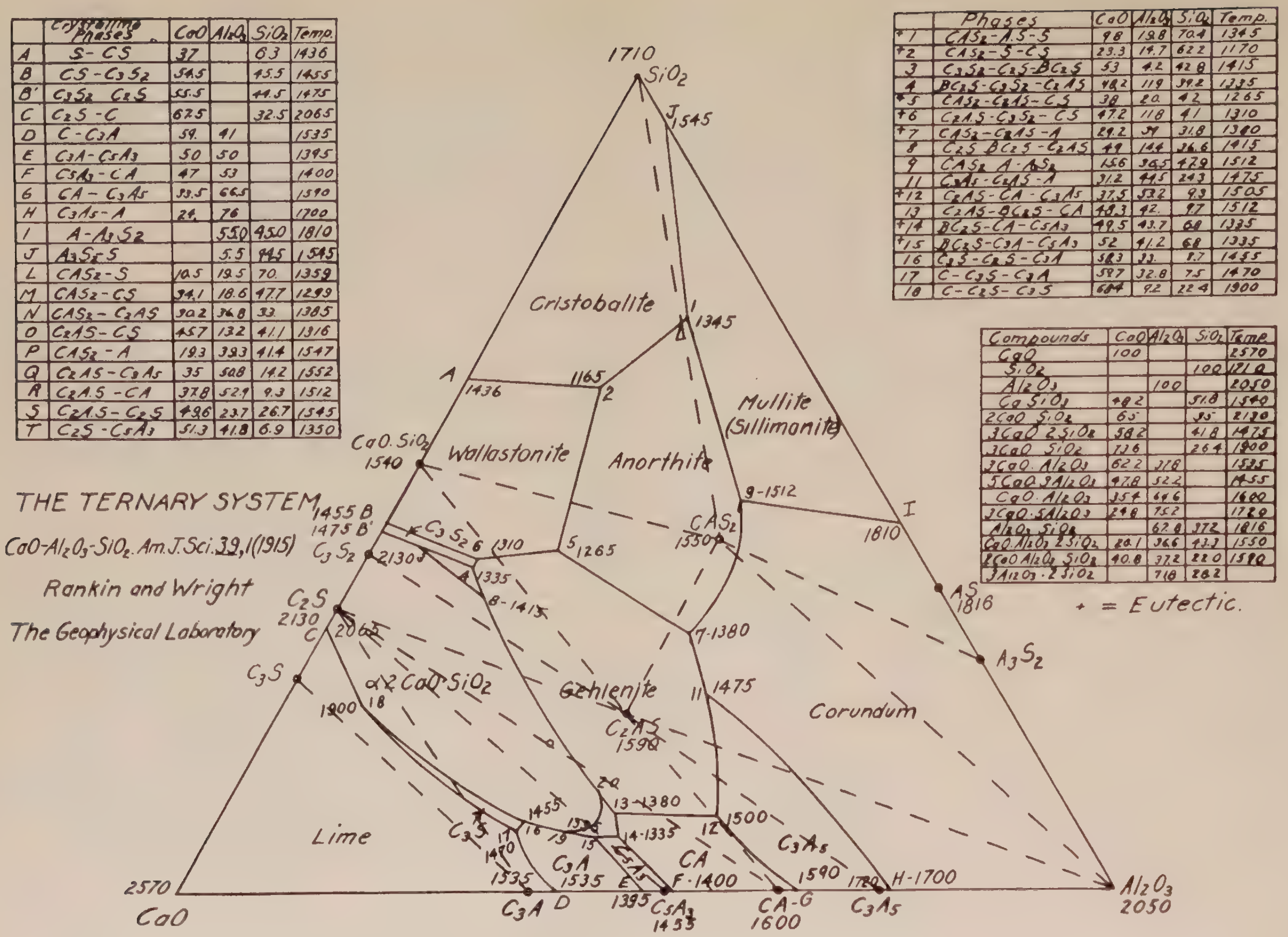
Tricalcium silicate is conceded to be the most important hydraulic compound in portland cement. The diagram, Figure 1, shows that tricalcium silicate does not appear on the liquidus in the two-component system. That means that it cannot be crystallized from a melt as the primary (first) crystal phase in mixtures of lime and silica. On cooling a melt of the composition of tricalcium silicate, lime crystals would first appear. Later, at a temperature of 2,065 deg. C., dicalcium silicate would appear and the two phases would crystallize together until all of the liquid *G* had disappeared. The two phases, lime and dicalcium silicate, would be stable until the temperature had dropped to 1,900 deg. C. at which temperature these two solid phases would react together to form tricalcium silicate. As the reacting phases at this temperature would both be solids, the reaction would be slow. If sufficient time were not allowed before cooling too far, equilibrium would not be reached and further cooling would result in a mixture of tricalcium silicate and lime and dicalcium silicate. This is one reason why so many investigators have failed to obtain tricalcium silicate by cooling down a melt of that composition; and some, particularly in Germany, have denied the existence of this compound. The best way to form the compound is to heat a mixture of lime and dicalcium silicate *below* 1,900 deg. C. As the diagram shows, even when once formed, the compound decomposes at this temperature to form lime and dicalcium silicate.

In the manufacture of portland cement the reactions are essentially those brought about by heating mixtures, and they take place largely in the solid state during the heating process. This, as has been indicated, is a most effective way to form tricalcium silicate.

Figure 1 shows that dicalcium silicate can exist in more than one form. It is well known that this mineral inverts with a sudden increase in volume from the high temperature to the γ or low temperature form on slow cooling. Certain factors tend to prevent this inversion. For example, sudden cooling of the high temperature forms from a sufficiently high temperature inhibits and frequently prevents the transformation of the high temperature form to γ dicalcium silicate. Often the inversion takes place some time after cooling, and when this happens the "dusting" or disintegration of a mass containing dicalcium may be observed.

The Three-Component System $CaO-Al_2O_3-SiO_2$

In the two-compartment system, compositions were represented on one axis and temperatures on the other. In a system consisting of three components, or end members, composition can be represented on a triangular diagram. Any point within the triangle expresses fixed proportions of the end members. A corner of the triangle represents 100 per cent of that component, and mixtures of any two



	Crystalline Phases	CaO	Al_2O_3	SiO_2	Temp.
A	S-CS	37		63	1436
B	CS-C_3S_2	54.5		45.5	1455
B'	C_3S_2 C_2S	55.5		44.5	1475
C	C_2S-C	67.5		32.5	2065
D	C-C_3A	59.	41		1535
E	C_3A-C_5A_3	50	50		1395
F	C_5A_3-CA	47	53		1400
G	CA-C_3A_5	33.5	66.5		1590
H	C_3A_5-A	24.	76		1700
I	A-A_3S_2		55.0	45.0	1810
J	A_3S_2-S		5.5	94.5	1545
L	CAS_2-S	10.5	19.5	70.	1359
M	CAS_2-CS	34.1	18.6	47.7	1299
N	CAS_2-C_2AS	30.2	36.8	33.	1385
O	C_2AS-CS	45.7	13.2	41.1	1316
P	CAS_2-A	19.3	39.3	41.4	1547
Q	C_2AS-C_3A_5	35	50.8	14.2	1552
R	$C_2A.S$-CA	37.8	52.9	9.3	1512
S	$C_2A.S$-C_2S	49.6	23.7	26.7	1545
T	C_2S-C_5A_3	51.3	41.8	6.9	1350

	Phases	CaO	Al_2O_3	SiO_2	Temp.
+1	CAS_2-$A.S$-S	9.8	19.8	70.4	1345
+2	CAS_2-S-CS	23.3	14.7	62.2	1170
3	C_3S_2-C_2S-BC_2S	53	4.2	42.8	1415
4	BC_2S-C_3S_2-C_2AS	48.2	11.9	39.2	1335
+5	CAS_2-C_2AS-CS	38	20	42	1265
+6	$C_2A.S$-C_3S_2-CS	47.2	11.8	41	1310
+7	CAS_2-C_2AS-A	29.2	39	31.8	1380
8	C_2S BC_2S-C_2AS	49	14.4	36.6	1415
9	CAS_2 A-AS_2	15.6	36.5	47.9	1512
11	C_3A_5-C_2AS-A	31.2	44.5	24.3	1475
+12	C_2AS-CA-C_3A_5	37.5	53.2	9.3	1505
13	C_2AS-BC_2S-CA	48.3	42.	9.7	1512
+14	BC_2S-CA-C_5A_3	49.5	43.7	6.8	1335
+15	BC_2S-C_3A-C_5A_3	52	41.2	6.8	1335
16	C_3S-C_2S-C_3A	58.3	33.	8.7	1455
17	C-C_3S-C_3A	59.7	32.8	7.5	1470
18	C-C_2S-C_3S	68.4	9.2	22.4	1900

Compounds	CaO	Al_2O_3	SiO_2	Temp.
CaO	100			2570
SiO_2			100	1710
Al_2O_3		100		2050
$CaSiO_3$	48.2		51.8	1540
$2CaO$ SiO_2	65		35	2130
$3CaO$ $2SiO_2$	58.2		41.8	1475
$3CaO$ SiO_2	73.6		26.4	1900
$3CaO.Al_2O_3$	62.2	37.8		1535
$5CaO$ $3Al_2O_3$	47.8	52.2		1455
$CaO.Al_2O_3$	35.4	64.6		1600
$3CaO.5Al_2O_3$	24.8	75.2		1720
Al_2O_3 SiO_2		62.8	37.2	1816
$CaO.Al_2O_3$ $2SiO_2$	20.1	36.6	43.3	1550
$2CaO$ Al_2O_3 SiO_2	40.8	37.2	22.0	1590
$3Al_2O_3 \cdot 2SiO_2$		71.8	28.2	

Figure 2. Triangular diagram for the ternary system CaO-Al_2O_3-SiO_2

are shown on the side involving those two. By dividing the triangle with lines parallel to each of the sides, the composition of any point on the diagram can be readily determined graphically.*

Figure 2 shows the ternary system CaO-Al_2O_3-SiO_2 as worked out by investigators at the Geophysical Laboratory. The sides of the triangle represent the three binary or two-component systems which, taken together, form the three-component system. Temperature can not be indicated as a variable within the plane of the triangle, but is represented in space in a direction perpendicular to the triangle, which then becomes the base of a space model. The more important temperatures on the diagram, such as melting points of compounds, and invariant points, are indicated in figures. From these data, it is possible to ascertain the directions of falling temperature along boundary lines, etc.

Besides the various binary compounds indicated on the sides of the large triangle, there are two ternary compounds formed in this system. These are anorthite ($CaO.Al_2O_3.2SiO_2$), and gehlenite ($2CaO.Al_2O_3.SiO_2$), the compositions of which are shown by black dots near the names. The irregularly bounded areas labeled lime, anorthite, corundum, etc., are the fields of primary crystallization of the various compounds. Any composition lying within one of these areas will deposit that compound from a melt on cooling as the first or primary crystal phase. The subtriangles formed by joining points representing the compositions of those compounds whose fields of primary crystallization meet are called composition triangles. Any composition which falls within one of these composition triangles will consist of the three compounds at the corners of the subtriangle when equilibrium is finally reached.

The progress of heating or cooling a composition on the ternary diagram can be followed in a manner similar to that indicated for the two-component system.*

As the three oxides, lime, alumina, and silica, constitute by far the greater part of the composition of portland cement, cement clinker can be considered from the standpoint of the ternary system. If cement compositions are expressed in terms of lime, alumina, and silica, and plotted on the diagram, it is found that they usually fall within the composition triangle C_3S-C_2S-C_3A,† generally in the vicinity of point 18. Neglecting the minor oxides, the diagram shows that when the portland cement mix is completely matured by heat it will consist essentially of the three compounds at the apexes of the composition triangle in which it falls.

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* "Since every point within the triangle has the property that the sum of the perpendiculars from that point to the sides of the triangle is equal to unity (the height of the triangle), the composition of a ternary mixture can be represented by fixing a point within the triangle such that the lengths of the perpendiculars from the point to the sides of the triangle are equal respectively to the fractional amounts of the three components present" (3).

(3) Findlay, A., "The phase rule and its applications," Longmans, Green & Co., New York City, 1923, p. 192.

*The method of making use of ternary diagrams in order to determine the reactions taking place, and the progress of heating and crystallization in the system, with a full discussion of the lime, alumina, silica system is given by Rankin and Wright (4) in a paper entitled, "The ternary system, lime-alumina-silica."

(4) Rankin & Wright, *Am. J. Sci.*, [4], 39, 1 (1915).

†Frequently in the discussion of equilibrium diagrams, such abbreviations are used: C = CaO, C_2S = $2CaO.SiO_2$, etc.

Inspection of the diagram shows that in heating a portland cement mixture consisting of lime, alumina, and silica, if the mixture falls within the composition triangle C_3S-C_2S-C_3A, the first liquid will form at 1,455 deg. C. (point 16 on the diagram). This is the case because the liquid at point 16 is the only liquid which can be in equilibrium with tricalcium silicate, dicalcium silicate, and tricalcium aluminate. In actual practice the temperature of liquid formation is lowered by the iron oxide and other minor constitutents which contribute to the liquid phase. As the temperature is increased the amount of liquid phase increases at the expense principally of tricalcium aluminate, and when all the tricalcium aluminate has disappeared the composition of the liquid changes along the boundary line 16-18, in the direction of 18. In clinkering, a temperature is never reached such that the entire mass is liquid, but the presence of the liquid phase greatly promotes the formation of tricalcium silicate.

One or two additional points which are made apparent from the diagram may be mentioned. For example, the final products of equilibrium in a portland cement mixture will be greatly influenced by a relatively small change in the proportion of lime. The diagram also shows that a small increase of lime in a clinker high in lime will greatly increase the refractoriness of the mixture, thereby making necessary either high temperatures or longer heat treatment at the same temperature. If the composition should be so high in lime as to fall within the composition triangle, C_3S-C-C_3A, it would be "over limed," and no amount of heat treatment could combine all the lime at equilibrium.

Four-Component Systems

The amount of iron oxide present in grey portland cement is sufficient so that its function can not be neglected. If this constituent is considered, grey cement compositions must be treated from the standpoint of four components, and properly fall into the four-component system, CaO-Al_2O_3-SiO_2-Fe_2O_3. Four components can be graphically represented in space as the apexes of a tetrahedron. The working out of the entire four-component system mentioned would be an almost impossible task, but portions of the system have been worked on by treating certain parts of it as two- and three-component systems, within the tetrahedron. The Portland Cement Association Fellowship at the Bureau of Standards has investigated the portion of the four-component system in which portland cements usually lie. As a result of their work a new compound, $4CaO.Al_2O_3.Fe_2O_3$, was identified and established as a constituent of grey cement clinker. On the basis of this work it is now possible to calculate, either graphically or algebraically, the mineral constitution of cement or cement clinker from an accurate chemical analysis.

Even a limited discussion of silicate equilibrium diagrams is not complete without a few words as to the method of working them out. Briefly, this is done by heating mixtures, the compositions of which have been prepared to represent definite points on the diagram and then examining with the petrographic microscope these heated compositions after annealing or quenching at different temperatures to determine the identity of the phase or phases present in the system at the temperature in question. Over 7,000 such heat treatments and petrographic examinations were made in working out the lime-alumina-silica system at the Geophysical Laboratory. Incidentally, this work was initiated and carried out in a fundamental study of natural minerals and rocks, but a vast amount of knowledge and information of great import to the portland cement industry, as well as those industries utilizing silicate slags in metallurgical processes, has resulted from this and other allied studies.

(*To be concluded*)

The Cement Industry Code

WHETHER voluntary co-operation shall be supplanted by compulsory control was the question before an all day meeting of NRA officials and representatives of the cement industry, at the Department of Commerce auditorium on July 11. Representatives of the industry said they regarded final decision of the question as vital to industry generally and that it might even affect the future of NRA itself.

"Writing a code is a process of give and take," said Charles F. Conn, of Philadelphia, president of the Cement Institute, "but does the give-and-take process mean that industry does all the giving and NRA does all the taking? We believe that NRA codes will succeed only to the extent that those who are bound thereby will and can abide by them. The failure of NRA to do anything to assist industry in the enforcement of trade practice provisions makes it doubly clear that the fate of this experiment in codes rests in the success of self-regulation."

The cement industry was cleared of alleged non-competitive practices by Barton W. Murray, deputy NRA administrator, in charge of the cement industry code which has been in effect since last November.

The meeting of July 11 came about as a result of General Johnson's having suspended Article XI of the code after President Roosevelt had given the code his signature last November. Cement dealers had requested the abolishment of this article, which defined what classes of cement were to be sold through dealers and what direct to contractors and other buyers. L. I. McQueen, of Pittsburgh, representing 40,000 building supply dealers, who was influential in having the article rescinded, urged its reinstatement and was supported by other spokesmen of the builders supply code authority.

When the hearing opened, NRA representatives had proposed 41 additional changes covering practically every article in the code. "These additional changes," said Mr. Conn, "would remove the code from the status of voluntary co-operation intended by the Recovery Act and constitute compulsory control of the industry instead. If the code presents a plan of self-regulation, it will, in large part, succeed in rehabilitating the industry. If, on the other hand, voluntary regulation is to be supplanted by imposed regulation, then we gravely doubt that the act or the code will work."

◆ EDITORIAL ◆

The Rotary Kiln Holds the Field

IN spite of the advent of the modern continuous shaft kiln brought out at the end of the World War and installed in a considerable number of cement manufacturing plants in Germany, Spain and other European countries, the rotary kiln continues to hold the dominating position in most of the cement-producing countries of the world.

In the Western Hemisphere the rotary kiln is employed to the virtual exclusion of other types. In England most of the plants employ the rotary kiln, for in practically all cases the newer plants installed this type, and many of the old plants were changed from the shaft kiln to the rotary when their cement-making equipment was modernized.

Originally the rotary kiln was little more than a simple tube or shell, with a kiln hood at one end through which passed a pipe for the passage of pulverized coal, oil or gas, and a feed pipe for the entry of raw materials at the other end.

This early type of rotary kiln had the disadvantage of high fuel consumption, but it had the distinct advantage of producing a clinker of high and uniform quality. Further advantages were that the process of burning was in full view of the operator and was under his control. By altering the speed of rotation, by changing the rate of feed of the raw material, or by varying the quantity of fuel or the force of the fuel blast, the operator was able to regulate the burning process to any necessary degree.

Quite naturally, these various features of the rotary kiln were improved from year to year; and the greatest improvements have been developed in the past ten years.

Notable among the improvements is the reduction in fuel consumption. Starting with a consumption of around 1,750,000 B.t.u. per barrel of clinker in dry-process operation, and well above 2,000,000 B.t.u. in the wet process, improvements have brought the figures down to less than half the early requirements.

These reductions in fuel requirements were realized through the improved utilization, in the kiln, of the clinker heat recovered from the coolers; through reduction in stack losses; and through reduction of heat losses by radiation from the kiln shell. Other important improvements to the rotary kiln include the reduction of power consumption and improvements in kiln operation and control.

Doubtless the rotary kiln will undergo further improvement, for the development of cement-manufacturing machinery is never at a standstill; but unless a complete revolution in cement-making is brought to the front, the rotary kiln will continue to dominate the field.

Mineralogy Throws Light on Portland Cement

IN his excellent and comprehensive new book on "Portland Cement," A. C. Davis, works managing director for Associated Portland Cement Manufacturers, emphasizes the growing need for a better knowledge of the mineralogical character of cement clinker.

The constituents of portland cement, as he explains, can readily be determined by the usual methods of chemical analysis. Such investigations show that good cements differ little in constitution, although there is considerable variation in the percentage of the several ingredients in different samples. But chemical examination alone does not enable the trained chemist or anyone else to determine whether a cement is of superior or indifferent quality in practical use. It would not be difficult to prepare a material containing the exact constituents of ordinary portland cement, but which would have no cementing properties whatever.

A comprehensive knowledge of chemistry is required in dealing with the production of portland cement, the author continues; but whereas chemistry has long been in the service of the cement industry, mineralogy is only now gradually entering this sphere. In consequence, the cement chemist passes from the chemical examination to the mineralogical, in his attempt to understand more thoroughly the precise answer to the question "What is portland cement?"

In the study of cement, mineralogy is proving a valuable aid, for it supplements the technical and chemical investigations. A good microscope has become an indispensable item in the equipment of the cement-testing laboratory. As is well known, the mineral constituents of rocks can be identified under the microscope by means of specially prepared thin sections, and with the aid of polarized light. These same methods are applied with equal success to thin sections of cement clinker.

Among the important disclosures resulting from these mineralogical studies, the identification of the two preponderating minerals of cement clinker is outstanding. These two are Alit and Celit—the former a solid solution of tricalcium aluminate and tricalcium silicate, and the latter a solid solution of dicalcium aluminate and dicalcium silicate.

The cement chemist is fortunate in this growing importance of mineralogy, for this development has enhanced his value to the industry. It is to be hoped that his importance will become more generally realized. It is a fact that on this side of the Atlantic he has not been given the recognition accorded him in Europe.

Puzzolanic Cements Offer Resistance to Sulphate of Magnesia

Perform Better Than Portland Cements Against Most Destructive Element of Sea Water—Investigator Urges Hardening of Concrete in Air for First Month

THE experiences of which an account is here given concerning the action of sulphate of magnesia on cement mortars were not a simple study of the problem, but experiences resulting from a series of studies of puzzolanic cements in sea water.

Subject Studied for Twenty Years

About 20 years ago, when the first articles appeared under the signature of the engineer, Eduardo de Castro, on puzzolanic cements, we began the study of this problem with the most careful attention. Several years were devoted to laboratory experimentation and to sea water experiments. Practically complete absorption of lime in puzzolanic cements was obtained by means of the formula—

$$\frac{SiO_2 + Al_2O_3}{CaO} \geqq 1$$

This formula approaches more closely to that of Vicat than to that of Lafuma, in Italy. Exceptions must be made in the case where the silica and the alumina occur in the puzzolanic material as independent elements, and in the case of those puzzolanas of the Santorin type, which are composed almost exclusively of silica and where one can accept the formula of Lafuma—

$$\frac{SiO_2 + Al_2O_3}{CaO} = 1$$

In other cases the puzzolanic material is a mixture of silica, of aluminum silicates, and other silco-aluminates of very complicated molecular combination, the lime being fixed in a manner analogous to that of the zeolites. One must approach the criterion of Vicat, and be limited to the following coefficient:

$$\frac{SiO_2}{Ca} = 1$$

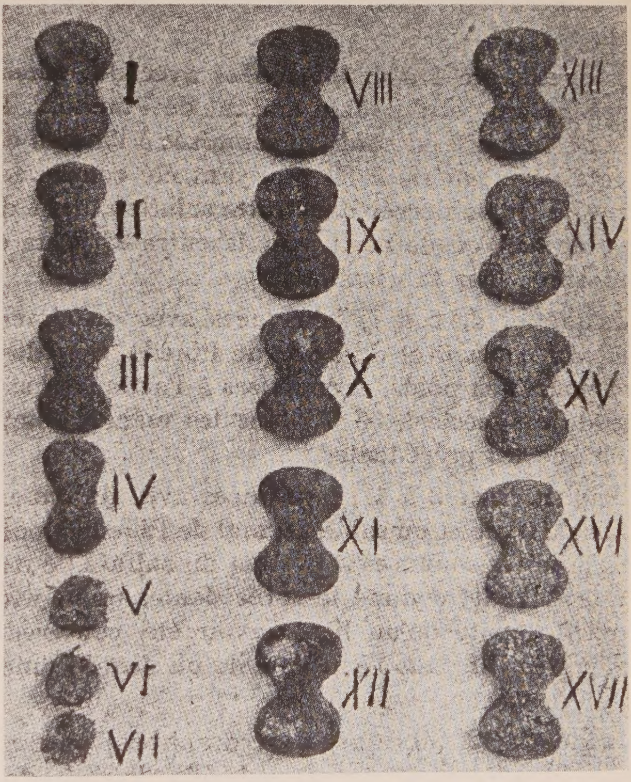
With this criterion we have seen that the cracks which appear in the large blocks of concrete submerged in sea water—as well as the swellings caused principally by the carbonate of lime and of magnesia and which stop up the cracks in portland cement concrete—do not occur in the submerged blocks of concrete made of puzzolanic cements. Little by little the cracks lose their importance, until they disappear completely, remaining barely discernible in the concrete blocks in which the cements used in the mixtures were puzzolanic cements conforming to the formula we have proposed.

Three-Year Tests in Concentrated Solutions

Having also seen effectuated the fixation of the lime, we have been willing to go further by changing the natural conditions and attacking the problem of mortars of portland and puzzolanic cements by the method of concentrated solutions of sulphate of magnesia. With this object in view we prepared a series of cement mortars shown in the accompanying illustration from a photograph of briquettes taken after having been under test for three years. The composition of the briquettes was as follows:

(1) Briquettes 1 to 4 were made with puzzolanic cement and standard sand from Pinedo, in the proportion of 1:3 by weight, and were subjected to the action of a 30 per cent solution of sulphate of magnesia. Prior to being submerged in this solution, the briquettes had been stored in sea water for the first 28 days and then in fresh water for one year.

(2) Briquettes 5 to 7 were made with ordinary portland cement and standard sand from Pinedo, in the proportions of 1:3 by weight, and subjected to the action of a 30 per cent solution of sulphate of magnesia under the same conditions as given in the paragraph immediately preceding.



Mortar briquettes of portland cements and puzzolanic cements after immersion in solution of sulphate of magnesia for three years

(3) Briquettes 8 to 11 were made with puzzolanic ce-

Translated from *Cemento* (Barcelona), December, 1933.

ment and standard sand from Pinedo, proportions 1:3 by weight, and subjected to the action of a 30 per cent solution of sulphate of magnesia, as in the preceding cases, but with this difference, that instead of having been stored previously in fresh water and in sea water, they were stored in air.

(4) Briquette 12 was made with ordinary portland cement and standard sand from Pinedo, in the proportions of 1:3 by weight, and subjected to a 30 per cent solution of sulphate of magnesia, after having been stored in air during the first month.

(5) Briquettes 13 to 16 were made of puzzolanic cement and standard sand from Pinedo, in the proportions of 1:3 by weight, and subjected to the action of a 10 per cent solution of sulphate of magnesia, after having been stored in fresh water for the first month, then in sea water for one year, before being submerged in the solution.

(6) Briquette 17 was made with ordinary portland cement and standard sand from Pinedo, in proportions of 1:3 by weight, and subjected to the action of a 10 per cent solution of sulphate of magnesia, under the same conditions as briquettes 13 to 16.

Requires Initial Hardening in Air

In view of the results obtained, one can easily comprehend the great advantage in storing the mortar briquettes in air before immersing them in the salt solutions. To what may this phenomenon be attributed? On first impression, it may be attributed to the action of carbonic acid. But if we take into consideration that after the age of one month the cement in the briquettes continues to harden, with the consequent release of free lime within the magnesia solution, we are more inclined to think that this neutralization of carbonic acid can not explain the fact of its conservation. If we add to this the fact that the destruction of briquettes in the magnesia solutions occurred after they had been stored either in fresh water or in sea water for one year, there is reason to suppose that the bicarbonates of these waters, which had been renewed periodically, as well as their capacity for dissolving, are able to eliminate the lime from the mortar briquettes and to render them more subject to attack. Therefore it may only be supposed that the setting in air, in the same manner as the hardening, must cause the formation of a matrix that is insoluble in the solutions of sulphate of magnesia.

Weak Solution Not So Destructive

The second important result which we are able to deduce is the important part played by the concentrated salts of magnesia in the destruction of the briquettes, since it is clear that in the proportion that the concentration diminishes the resistance of the mortar increases. But this resistance to destruction does not follow what might be called a law of direct proportion. For instance, if in three years the amount of disintegration shown in the illustration is produced, the blocks of concrete in the north causeway at the port of Valencia, which have been in place 18 years, should be completely disintegrated (sea water has a salt concentration of 4 per cent). Meanwhile, however, these blocks of concrete remain intact, as the annual inspection of them has demonstrated.

Another interesting result which may be deduced, and which was discovered during this experimentation, is that conclusions drawn when cements are subjected to rapid tests may be very misleading. Concrete may resist perfectly, and over a long period, a weak concentration such as the sea water at Valencia noted above, and yet be destroyed in a comparatively short time in a stronger concentration.

Puzzolanic Cements More Resistant Than Portlands

The third lesson which these experiments taught us, is the much greater resistance to destruction by sea water obtained with puzzolanic cements than with ordinary portland cements. There is no doubt that the setting of portland cement in the presence of puzzolanic materials results in the formation of a matrix more resistant to the action of sulphate of magnesia. This point must be insisted upon, and studies must be continued with the view of eventually arriving at a definite solution of the problem. If, in the construction of various structures in sea water, it appears that we have arrived close to the limit, in the structures which unhappily are encountered so frequently in soil containing sulphates, one can not find the complete answer in portland cement.

Why Curing in Air Is Important

This point granted, when the writer considers these experiments as a whole he will recommend the employment of puzzolanic cement for any concrete construction work in soils containing sulphur water, and that such work should be protected from the sulphur water until the concrete has hardened in air for a month. And yet the writer immersed in fresh water and in sea water some of these briquettes which had remained undamaged in the 30 per cent solution of sulphate of magnesia, having been immersed after aging for one month in air. After one month of this accidental immersion they were again immersed in their original 30 per cent solution of sulphate of magnesia. Imagine our surprise when, at the end of 4 or 5 months, they began to disintegrate the same as the others.

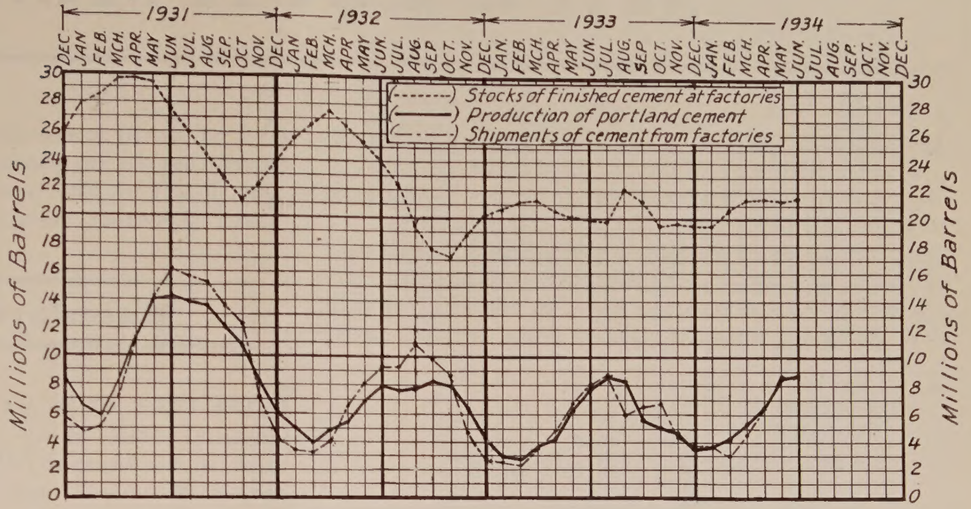
To what can we attribute such action? We have already expressed the opinion as to why storage in air prevents the destruction of concrete by sulphate of magnesia, and this experience seems to confirm that opinion. The explanation is that the cement, while hardening in the presence of water, forms a matrix differing from that which it forms when hardening in air, the former being more vulnerable to attack by the sulphate than is the case with the latter. Since this condition exists from the exterior to the interior of the mortar briquettes, without producing swellings of any kind, little by little the exterior coating of the water-cured specimen is disintegrated, as one may see clearly in briquette specimens 1 to 7 (the first column) in the illustration.

Cotton Sacks Used in 1933

MORE than 100,000,000 cotton sacks were used for shipment of cement in 1933, according to figures furnished by cement manufacturing interests, in discussing the use of cotton bags for the packaging and shipment of cement at tax hearings earlier this year in Washington, D. C., of the Agricultural Adjustment Administration, U. S. Department of Agriculture.

Cement Statistics for June

PRODUCTION of portland cement in June, 1934, showed an increase of 12.6 per cent and shipments an increase of 7.0 per cent, as compared with June, 1933. Portland cement stocks at mills were 8.1 per cent higher than a year ago.



Relation of Production to Capacity (Per Cent)

	The Month	Twelve Months
June, 1934	39.8	27.1
June, 1933	35.2	26.0
May, 1934	37.5	26.7
April, 1934	29.6	25.9
March, 1934	23.0	25.0

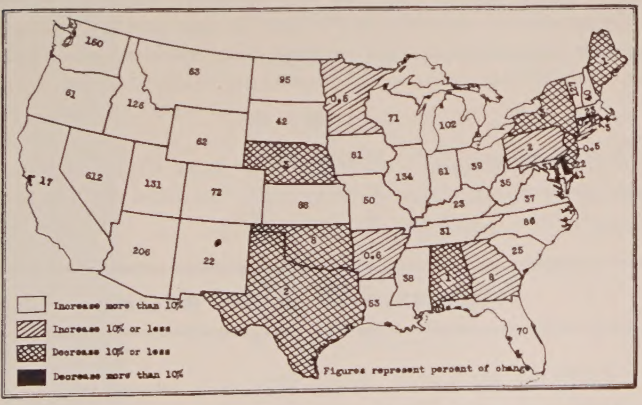
Production, Shipments and Stocks of Finished Portland Cement (Barrels)

	1933	1934
Production, June	7,804,000	8,786,000
Shipments, June	7,979,000	8,539,000
Stocks at end of month	19,936,000	21,547,000
Production for year to date	27,668,000	37,088,000
Shipments for year to date	27,927,000	35,163,000

In this statement of relation of production to capacity the total output of finished cement is compared with the estimated capacity of 163 plants at the close of June, 1934, and of 164 plants at the close of June, 1933.

Only One Black State Remains in Cement Map

DELAWARE was the only black state remaining in the cement map of the United States, as of May 31. Black areas show states in which cement shipments for the 6-month period ending on May 31 were more than 10 per cent below the corresponding period of the year before. Seven other states recorded decreases of 10 per cent or less. Of the remaining states, 34 record increases ranging from 17 to 612 per cent, while 6 states report increases of 10 per cent or less. The tabulation presents a comparison with previous 6-month periods:



Period considered	Number of States Showing decrease	Number of States Showing increase
6 months ending Jan. 31, 1934	34	14
6 months ending March 31, 1934	17	31
6 months ending May 31, 1934	8	40

How Duration of Grinding May Affect Setting Time

INVESTIGATIONS conducted by K. Koyanagi and described by him in an article in *Zement* (No. 22, 1933) throw further light on the cause of reduction in setting time. Several years ago, Koyanagi points out, Schachtschabel suggested that this reduction may be due to the dehydration of some of the gypsum retarder during grinding. Koyanagi's investigation has led him to conclude that, during lengthy periods of grinding, flakes of compressed cement powder are formed from the finest fraction and that considerable quantities of gypsum may become enclosed in these flakes. The enclosed gypsum is not dissolved, resulting in a deficiency of calcium sulphate in the mixing water. This deficiency is believed to be the reason for the accelerated setting of the cement.—From *British Science Abstracts*, November, 1933.

New Officers of S. C. I.

THE American Section of the Society of Chemical Industry announces the election of the following officers to serve for the year ending June 1, 1935:

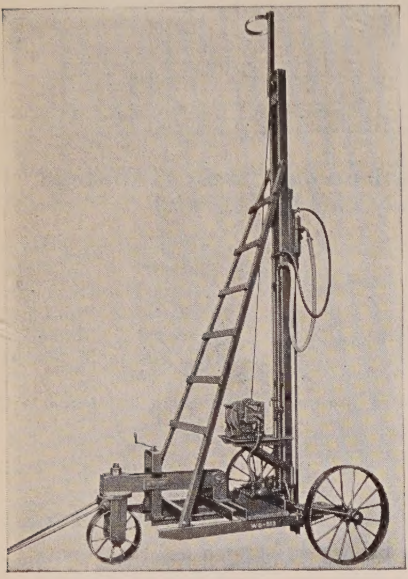
Chairman: Robert J. Moore.
Vice Chairman: W. D. Turner.
Hon. Secretary: Foster D. Snell.
Hon. Treasurer: J. W. H. Randall.

In addition, five new members were elected to the Executive Committee to take the place of retiring members. Those newly elected are Lincoln T. Work, Wallace P. Cohoe, Albert E. Marshall, James G. Vail and Charles A. Lunn.

MILL EQUIPMENT

AN improved type wagon drill for facilitating the drilling of deep drill holes in quarries and general rock excavation, has recently been announced by the Worthington Pump and Machinery Corporation of Harrison, N. J.

The new machine incorporates an adjustable drill steel centralizer, an exclusive feature, they say, which greatly reduces the time and labor necessary in collaring the drill holes. Another innovation claimed is the leveling device permitting the adjustment of the drill tower to the vertical position when the rig is set on uneven ground, thus eliminating blocking up of the wheels. The machine can be furnished with either an air hoist or a hand winch for raising or lowering the drilling engine and either a hand winch or block and fall for handling the drill steel.



Standard Worthington wagon drill

While the standard type is built with three wheels, it can also be furnished with four, for running on transverse track. Both are constructed to be converted to skid-type if desired. The drilling engine can be furnished for either light or heavy, wet or dry drilling, according to the manufacturers.

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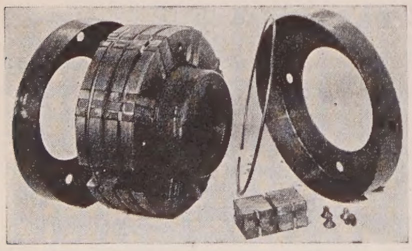
FLEXIBLE Couplings — Type WH — is a new general purpose coupling described in a 2-page illustrated leaflet by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. It is designed for use in connection with gearmotors, speed reducers, and other industrial drives, requires no lubrication, is easily inspected and is safe in operation, they say.



Westinghouse flexible couplings

AN improved screen filter is now being incorporated in Oxweld oxygen regulators, the Linde Air Products Company, New York City, announces. This improvement gives greater protection against foreign matter.

◆ Manufacturers' News ◆

LINK-BELT COMPANY, Chicago, has a noteworthy industrial exhibit at this year's Century of Progress Exposition in the General Exhibits Building, where the company's mechanical materials handling machinery and positive power transmitting equipment are portrayed in beautiful colored illuminated glass pictures; in working models that hold the attention of young and old; in dioramas; and in actual machinery units, a number of which can be operated with ample opportunity to observe how each mechanism works.

The Link-Belt exhibit at the Century of Progress Exposition

The exhibit has been thought out to appeal to all ages, man or woman.

The working models include a pivoted bucket conveyor for handling coal, ashes, etc.; a crawler dragline handling dirt; and a rotary railroad car dumper. Crawler cranes and excavating shovels, and a unique new positive variable speed transmission, are among the various additional equipment the company is displaying this year.

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INGERSOLL-Rand Company, New York City, announces the acquisition of the turbo-blower business of the General Electric Company, Schenectady.

◆ Industrial Literature ◆

JENKINS Bros., New York City, has recently prepared an unusual piece of literature—a twelve-inch cut-out replica of a Jenkins standard iron body gate valve.

This cut-out is next best to having the real Jenkins gate for inspection, as it provides an exact reproduction of both the exterior and the mechanism of a big, heavy Jenkins valve. An accurate listing, they say, of the features of Jenkins design and construction also is given.

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SQUIRREL Cage Induction Motors is a new leaflet just published by Allis-Chalmers Mfg. Co., Milwaukee, Wisconsin.